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THE REPAIR OF CLEFT PALATE

CONCERNING THE PALATINE INSERTION OF THE SUPERIOR CONSTRICTOR MUSCLE OF THE PHARYNX AND ITS SIGNIFICANCE IN CLEFT PALATE; WITH REMARKS ON THE "PUSH-BACK OPERATION"

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THE palate of man varies considerably in length without interfering with normal speech; yet there are limits to its length above or below when speech becomes defective. We are not concerned here with cases of long palates. Our theme is the short palate. A study of cases with shortened palates has been most helpful in changing our previous views as to the correct operative procedure for cleft palate. It has been generally accepted that most cleft-palate patients have a shortened palate. Cleft velum alone and cleft palate which extends as far forward as the anterior palatine foramen are usually shorter than lip-jaw-palate splits.

On studying speech in patients after cleft-palate operations, one is impressed by the fact that the best speech results are obtained in cases in which the velopharyngeal closure is complete. Investigation of the quality of speech after successful cleft-palate operations reveals the fact that the variance in speech is dependent in part upon the variance in length of the palate, the length of the palate controlling to a great extent the efficiency of velopharyngeal closure. The greater the efficiency of this closure the more satisfactory the speech. Insufficiency of velopharyngeal closure is dependent upon the distance between the velum and the pharyngeal wall. Passavant's cushion, which is formed by the pterygopharyngeus portion of the superior constrictor muscle of the pharynx, bulges forward as a distinct ridge in some cases of cleft palate, while in others this cushion is scarcely noticeable. Curious as it may seem, patients with cleft velum (Fig. 1) frequently have poor speech results whereas those with complete split palates not infrequently have excellent speech results.

We have had under our care two unfortunate patients in whom there had occurred a complete destruction of the nose, upper lip and turbinate bones. As a result of this extensive deformity, the nasopharynx was completely exposed to view (Fig. 2) and velopharyngeal closure could readily be studied. When these patients made efforts to pronounce the non-nasal sound "Ah" one could see that the pharynx was raised by contraction of the pharyngeal elevator muscles, and the velum could be observed as it was raised upward and backward by the levator and tensor palati muscles. A definite circular

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constriction of the nasopharynx (Fig. 3) was evident. This circular pharyngeal constriction was sphincter-like, similar to the sphincteric action of the sphincter muscles in other parts of the body. (Fig. 4.)

In one of these cases the posterior pharyngeal wall bulged markedly forward exhibiting Passavant's cushion; in the other case the cushion formation was rudimentary. In each case, the sphincteric closure of the nasopharynx was complete. So perfect was this closure that light could not be transmitted into the mouth from a diagnostic lamp introduced into the nasal
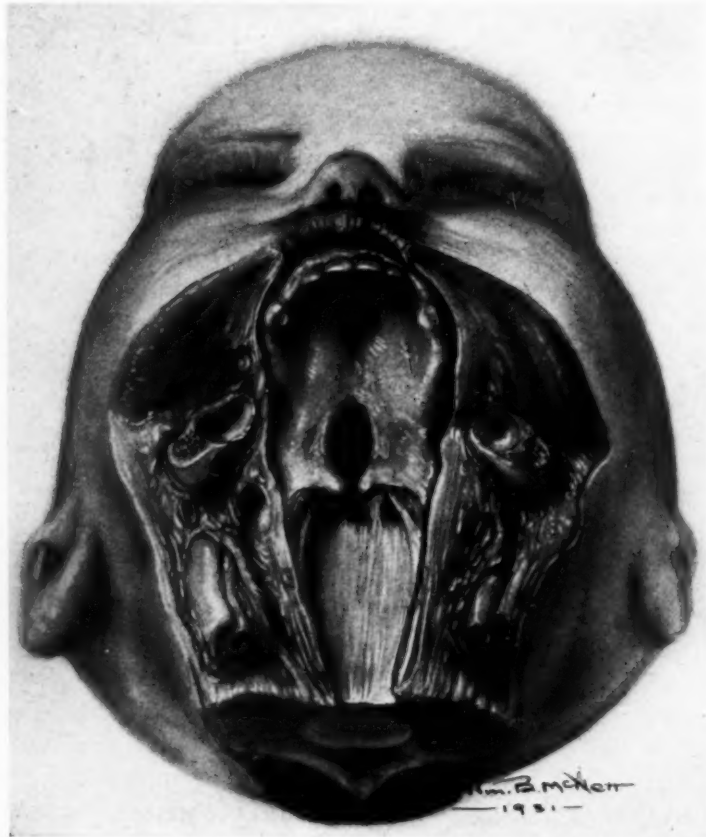
FIG. 1.—Artist's drawing of a cleft velum in a child about two years old.

chambers. This curious yet hitherto unrecognized function of the nasopharynx during speech led to a thorough study of the surgical anatomy of the normal pharynx and that of the pharynx in cleft-palate cases before and after operation. This study was supplemented with a review of the literature.

The standard works in anatomy (Fig. 5) have omitted in their descriptions an important insertion of the superior constrictor muscle of the pharynx. This insertion sheds new light on the physiology of the pharynx during speech and explains in part the inability of cleft-palate patients to speak distinctly after cleft-palate operations. Our dissections of the superior

FIG. 2.

A   *B*

FIG. 2*A*.—Photograph of the same patient with the nasopharynx exposed. Note that the "palato-pharyngeal-sphincter" is closed. The tongue is raised during this closure. *B*.—Photograph of a patient with complete destruction of the nose, upper lip and turbinate bones. Note that the naso-pharynx is exposed and the "palato-pharyngeal-sphincter" is open.
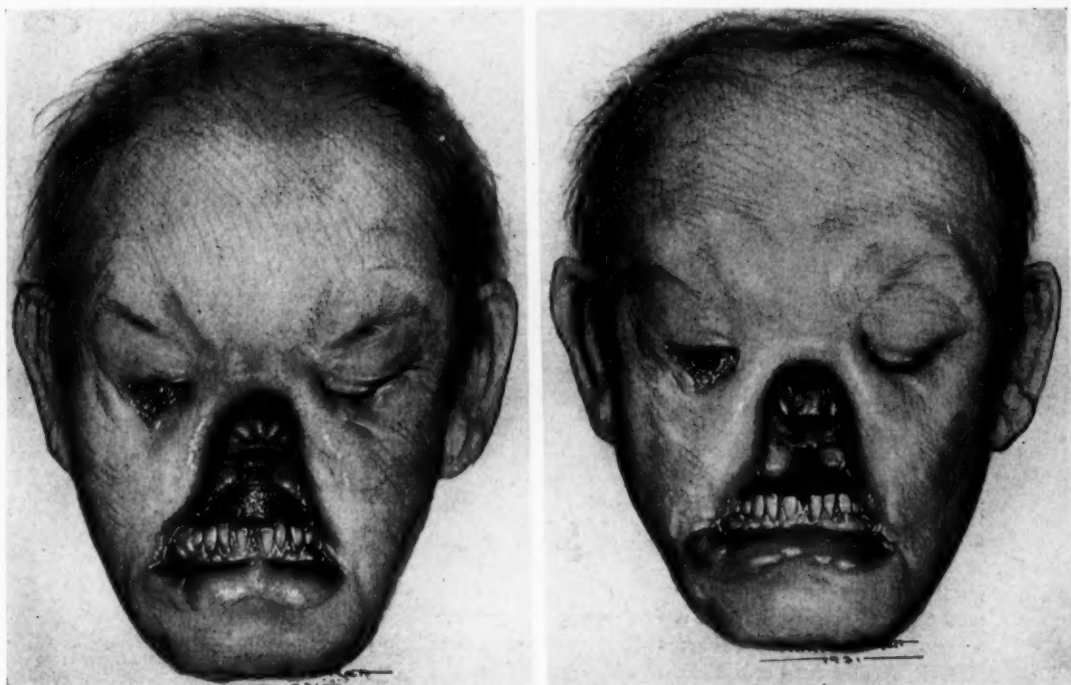
FIG. 3.

A   *B*

FIG. 3*A*.—Artist's drawing of the same patient with the nasopharynx exposed. Note the "palato-pharyngeal-sphincter" which is closed. The closure of this sphincter is complete. *B*.—Artist's draw-ing of the same patient with the nasopharynx exposed. Note the "palato-pharyngeal-sphincter" which is open.

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constrictor muscle of the pharynx and of the velum, in cleft-palate patients, and in normal individuals proved conclusively to us that this muscle is inserted in an intricate fashion into the nasal surface of the velum at the site of the insertion of the levator palati muscle and that in the normal state the fibres of one side interlace with those of the opposite side, thereby forming a definite muscular ring between the nasopharynx and the oropharynx. This fact unquestionably accounts for the circular sphincteric action seen in the two patients previously referred to.

The superior constrictor muscle of the pharynx is composed of the pterygopharyngeus, buccopharyngeus, mylopharyngeus and glossopharyngeus muscles. (Fig. 6.) In addition,
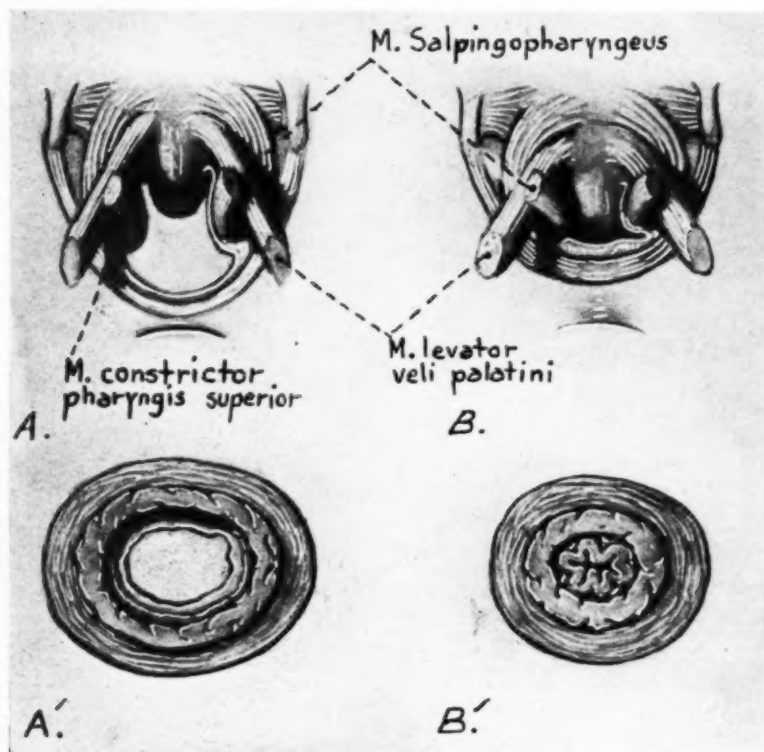
FIG. 4.—Artist's drawing of the "palato-pharyngeal-sphincter." A.—Shows the sphincter open, while B depicts it when closed. A' depicts the pylorus open, while B' shows it closed.

it has other accessory muscular slips. These accessory muscular strands when present assist in elevating the pharynx. However, one or more are frequently missing.

The pterygopharyngeus portion arises from the pharyngeal raphe. (Fig. 7.) Starting about 1.25 centimetres to 2 centimetres below the pharyngeal tubercle of the occipital bone, it runs outward towards the pterygoid plate of the sphenoid bone and assumes a curve on each side of the mid-line. As the muscle approaches the mesial pterygoid plate it divides into two slips. (Fig. 8.) The first of these is short and inserts into the lowermost aspect of the posterior border of the mesial pterygoid plate and the hamular process. The longer slip lying mesial to the former runs inward and forward to insert into the palatine aponeurosis with the palatine insertion of the levator palati muscle. The fibres of one side interlace with those of the opposite side at the site of

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insertion of the levator palati muscles (Fig. 9), a site which forms a common blending of the palatal muscles into the palatine aponeurosis. It is this palatine insertion of the superior constrictor muscle of the pharynx which completes the pharyngeal ring, an interesting anatomical fact omitted in the description of this muscle by the anatomists. This muscle which constitutes the upper fasciculus of the superior constrictor muscle of the pharynx forms Passavant's cushion and produces the sphincteric closure between the oropharynx and the nasopharynx.

In passing, we may remark that the pterygopharyngeus portion of the superior constrictor muscle of the pharynx was methodically described in 1863 and 1869 by Passavant, for whom this cushion is named. This cushion
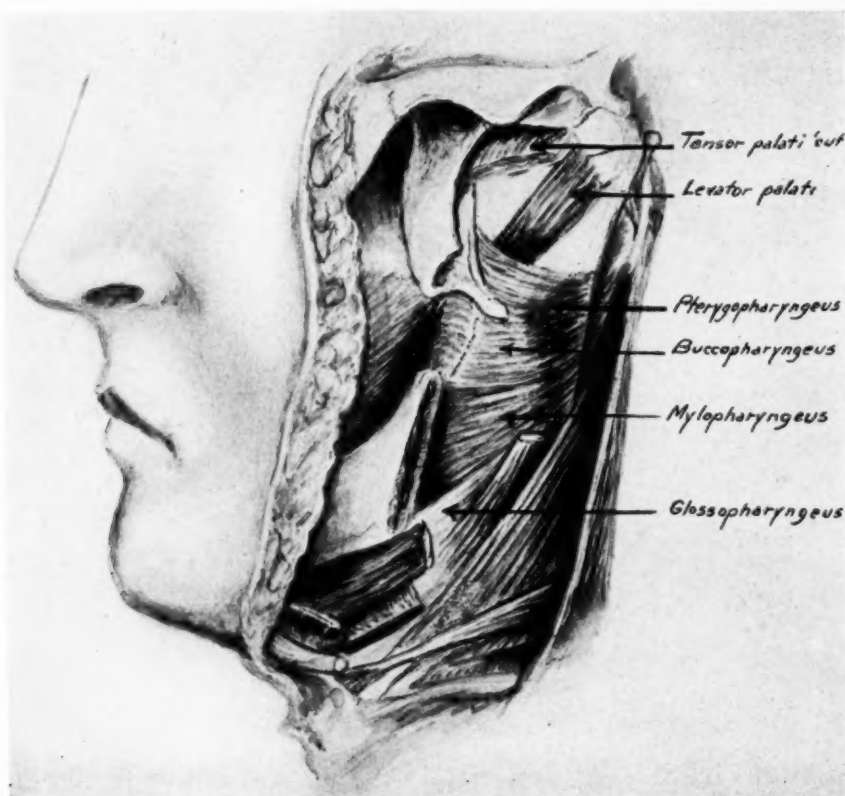
Fig. 5.—The superior constrictor muscle of the pharynx as depicted in the standard works on anatomy. Note that the palatine insertion of the pterygopharyngeus portion of this muscle is omitted.

formation was depicted before in 1805 by Sandifort in the illustrations (Fig. 10) appended to his work on deglutition entitled "Deglutitionis Mechanismus, Verticalis Sectione Narium, Oris, Faucium, Illustratus." Czermak, Hyrtl, Merkel, von Luschka and others have studied velopharyngeal closure, but to Passavant belongs the credit for giving the first comprehensive description of this mechanism in the normal and in cleft palate.

In 1879, Voltolini described the sphincteric action of the superior constrictor muscle of the pharynx. He emphasized the fact that the contraction

of the superior constrictor muscle of the pharynx is continued into the palate through the action of the levator palati and palatopharyngeus muscles. In 1880, Falkson discussed the sphincter-like closure of the nasopharynx and agreed with Voltolini on the action of this mechanism. Curious as it may seem, this palatine insertion of the superior constrictor muscle of the pharynx has been omitted from the writings of anatomists. As a matter of fact, physiologists likewise ignored the function of this muscle. We have observed this interesting palatine insertion of the superior constrictor muscle of the pharynx since 1926 and since then we have devoted considerable time and

m. tensor palati
Eustachian tube
m. levator palati
n. pterygopharyngeus
(palatine insertion)
hamulus pterygoideus
m. pterygopharyngeus
(pterygoid insertion)
m. buccopharyngeus
m. mylopharyngeus
m. glossopharyngeus
m. buccinator
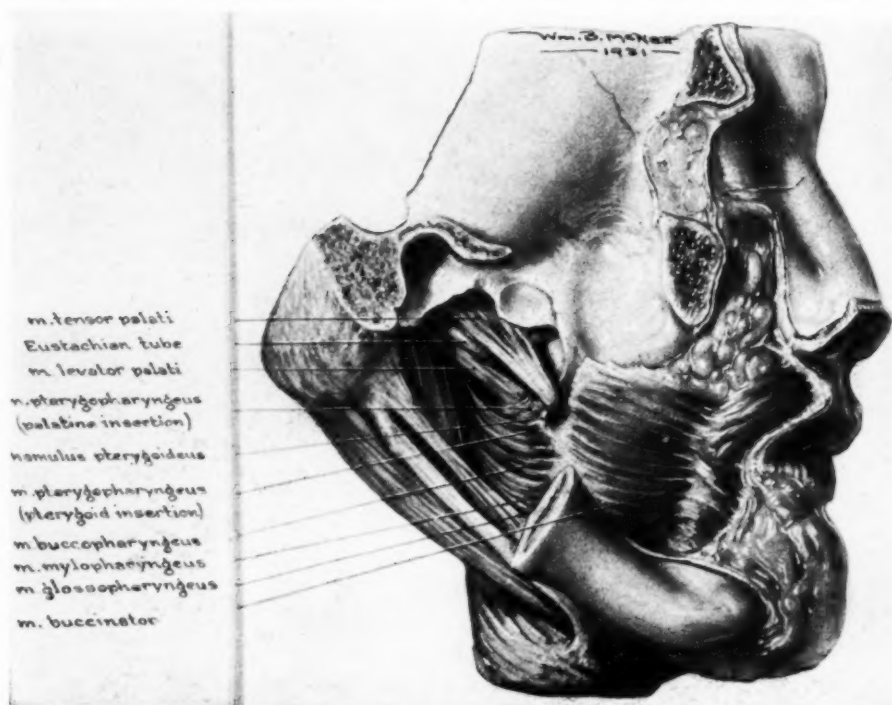
FIG. 6.—Lateral view of a dissection of the pharynx, showing the pterygopharyngeus portion of the superior constrictor muscle of the pharynx which inserts into the soft palate and the mesial pterygoid plate.

study to the subject of velopharyngeal closure. It is difficult to come to a definite conclusion until we were privileged to examine the two patients in whom the nasopharynx was exposed. Since the 'eighties, very little consideration has been given to the pterygopharyngeus portion of the superior constrictor muscle of the pharynx. It is apropos to mention here in this connection Wardill and Whillis, whose anatomical·investigations reveal similar observations to our own.

In 1928, Wardill stated: "On examination of almost any unoperated case of cleft palate during pronunciation of 'Ah' with the mouth wide open a prominent ridge is seen running transversely across the posterior pharyngeal wall to appear into the upper reaches of the soft palate . . . Passavant was

the first to describe this. If the bifid uvula be held aside during this movement, the outer end of the ridge is seen to enter the palate laterally to the muscular belly at the insertion of the levator on that side. The muscle appears to form part of the soft palate and in contracting it might be expected to exert some traction on this structure. This view is compatible with what we know of its function as part of the nasopharyngeal valve or sphincter. Dissections of the pharynx of man and animals have shown this to be correct. With the help of my colleague, Mr. James Whillis, the superior constrictor muscle has been shown to arise not only from the usually
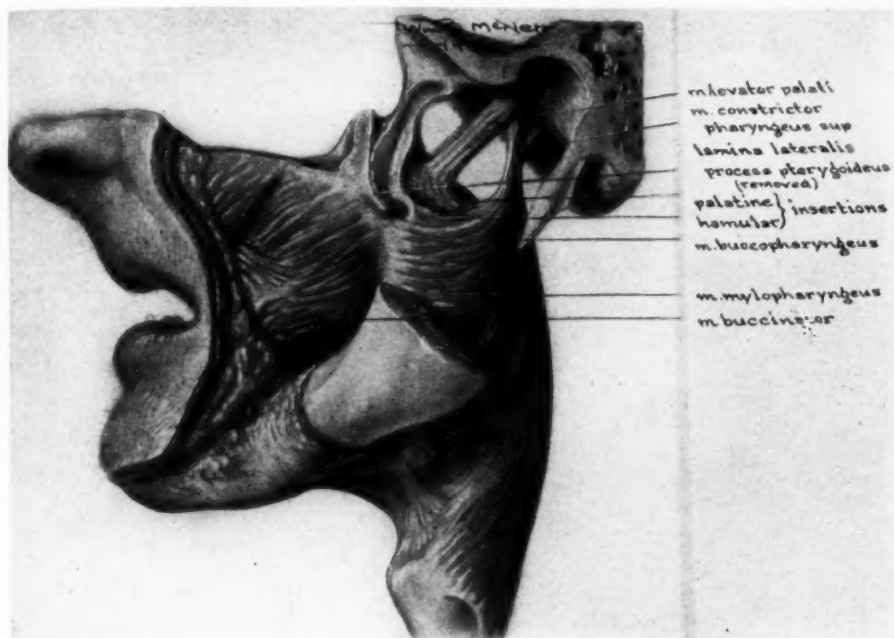
Fig. 7.—Lateral view of a dissection of the pharynx, showing the palatine and pterygoid insertions of the pterygopharyngeus muscle. The lateral pterygoid plate and the tensor palati muscle have been removed.

described situation but also from the palatal aponeurosis; a small fasciculus emanates from this situation to blend with the main portion of the muscle posteriorly . . ."

In his report entitled "a note on the muscles of the palate and the superior constrictor," Whillis suggested in 1930 that "the most suitable name for this muscle, if it merit a place in terminology, is that of a 'palato-pharyngeal-sphincter,' as its action appears to be that it assists in shutting off the nasopharynx by producing the ridge of Passavant, on the posterior pharyngeal wall."

In cleft palate, the anterior segment of the pharyngeal ring is split and the separated ends are spread apart. (Fig. 11.) The cleft palate assumes the shape of a narrow horse-shoe with the opening directed backward. The borders of the defect in this case take the shape of one side of the horse-shoe

with the convexity directed away from the median line. We are led to believe from this that each half of the palate is shortened by a forward and outward pull of the tissue. The dissections of cleft-palate subjects which we have made coupled with our studies of cases after the performance of the von Langenbeck operation convince us that the tensor palati muscle is shorter in cleft-palate cases than in normal individuals. The independent pull exerted on each side by this shortened muscle drags each half of the cleft velum forward and outward, causing the tips of the cleft uvula to point towards the median line. This is especially noticeable when the velum alone

levator palati
(cut)

tensor palati

hamulus pteryg

m. pterygo-
pharyngeus
(hamular insertion)

m. pterygo-
pharyngeus
(palatine insertion)

levator palati
(cut)

velum palati
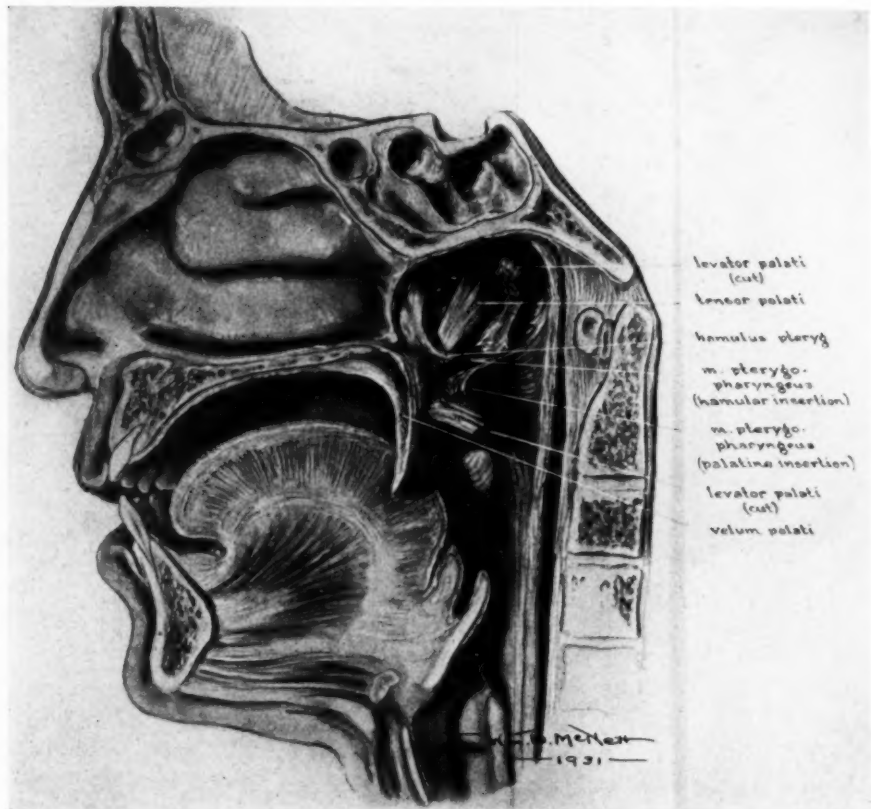
FIG. 8.—Sagittal section of the head to show the lateral wall of the pharynx. Note the two slips of insertion for the pterygopharyngeus portion of the superior constrictor muscle of the pharynx.

is cleft. Each half of the cleft palate is continuous with the corresponding arm of the cleft pharyngeal ring. The shortening of each half of the velum just mentioned tends to drag the corresponding arm of the pharyngeal ring forward and outward, thereby flattening it on each side and increasing the diameter of the nasopharynx in all directions. The cleft superior constrictor muscle of the pharynx in cleft palate is thus unable to produce the desired sphincteric action between oropharynx and nasopharynx, a function so essential for normal speech.

While Dorrance divided the hamular process in all his cleft-palate operations since the year 1914, the full significance of the influence exerted by this procedure on velopharyngeal closure was not properly interpreted or appreciated until we made our anatomical studies. Division of the hamular process will release the tension produced by the tensor palati muscle and thus permit mesial displacement of the palatine insertion of the superior constrictor muscle of the pharynx. (Fig. 12.) The function of the tensor
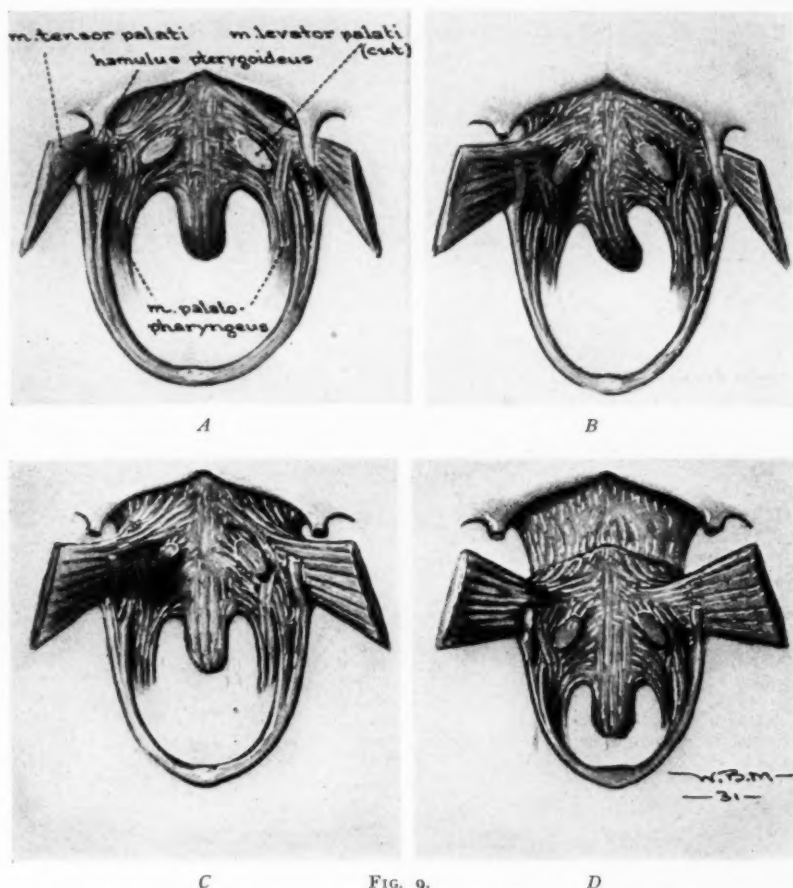
FIG. 9A.—Dissection of pharynx in a congenitally short palate. B.—Division of one hamular process removes tension of tensor palati muscle. C.—Note how division of both hamular processes removes all tension of tensor palati muscles, and places palatine insertion of superior constrictor in desired position to close the nasopharynx. D.—Backward displacement of the palate with division of hamular processes restores "palato-pharyngeal-sphincter" in cases afflicted with congenital shortening of the palate.

palati muscle will also be altered from that of a tensor to that of an elevator and render it an assistant to the levator palati muscle. By this means lateral tension is removed and the anterior ends of the cleft pharyngeal ring in split palate can be approximated at the mid-line, thereby restituting the divided velopharyngeal sphincter.

It is interesting to mention here that this lateral tension met with in cleft
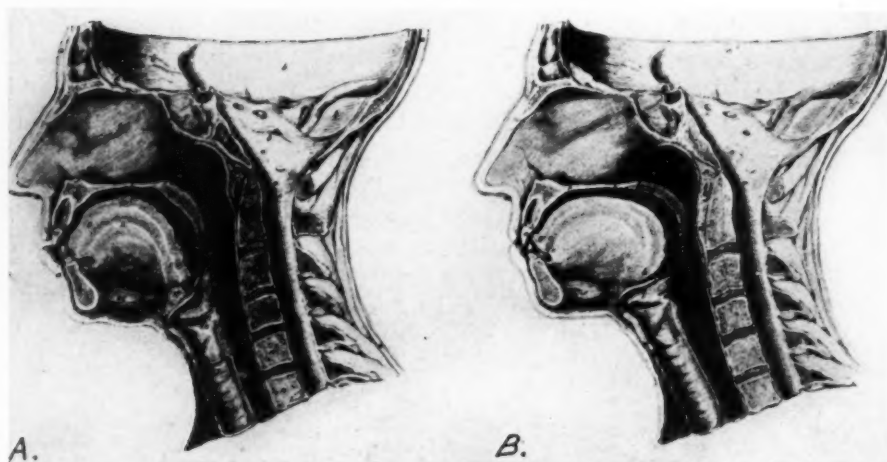
FIG. 10.—Sandifort's illustrations published in 1805. *A* shows the nasopharynx open.
B shows the "palato-pharyngeal-sphincter" closed. Note the bulging forward of Passavant's cushion
formed by contraction of the pterygopharyngeous portion of the superior constrictor muscle of
the pharynx. Taken from Sandifort's "Deglutitionis Mechanismus, Verticalis Sectione Narium,
Oris, fauciunn, Illustratus."
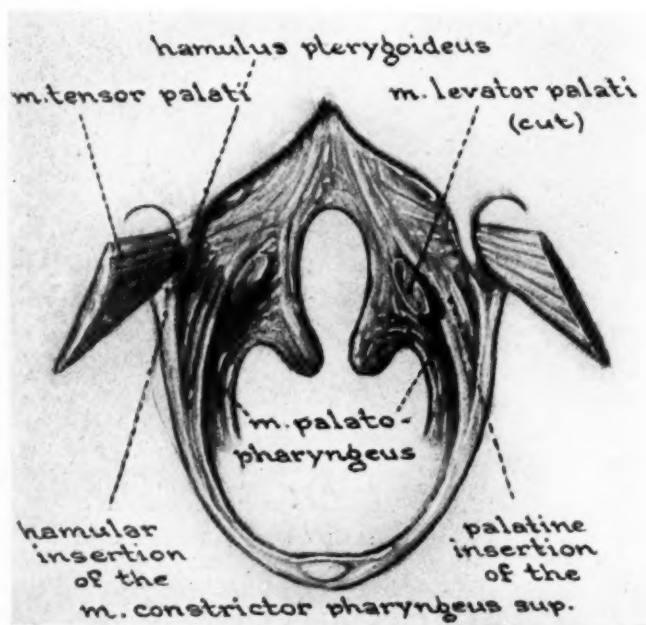
FIG. 11.—Dissection of the cleft velum in a child about two years
old to show the split pharyngeal ring. Note the palatine insertion of
the superior constrictor muscle of the pharynx. Each half of the split
velum is shortened by outward and forward pull of the tensor palati
muscle.

palate was observed by the early pioneers of cleft-palate surgery. Malgaigne attributed it to a "muscular action which is not easily accounted for." Sir William Fergusson held the same view. However, the lateral and forward pull of this muscle was recognized as early as 1846 by Liston, who emphasized the necessity of dividing the tendon of the tensor palati muscle to
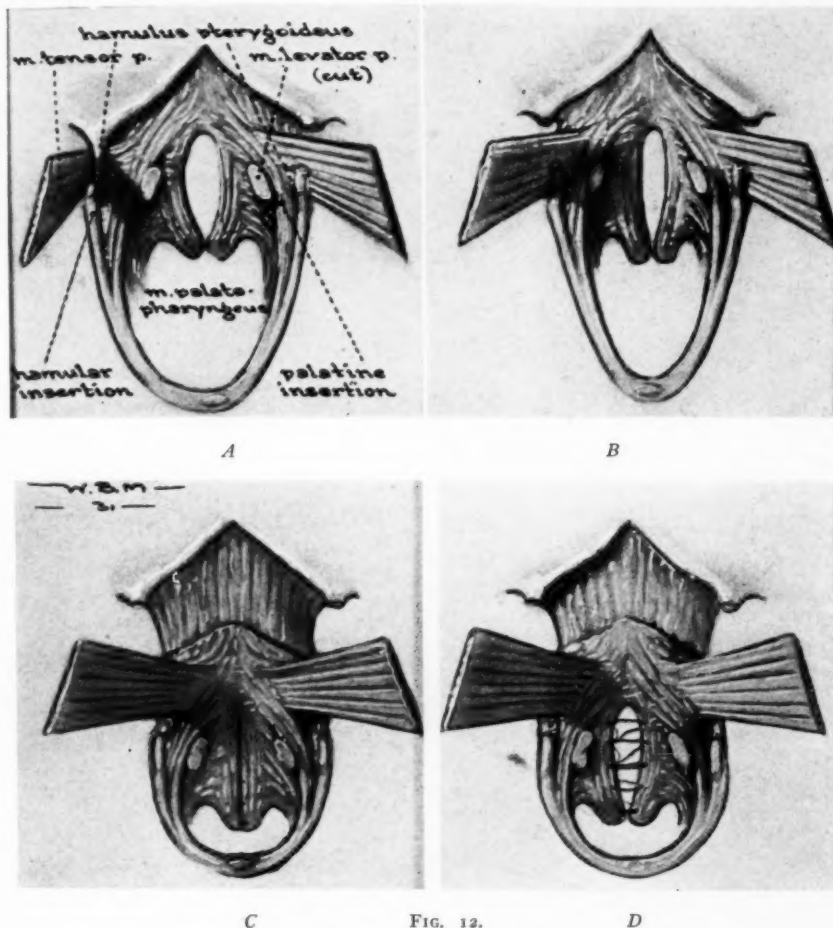
FIG. 12A.—Division of hamulus on one side removes tension of tensor palati muscle. B.—Division of hamulus on both sides removes tension of tensor palati muscles. C.—Note how backward displacement of palate with division of hamular processes restores "palato-pharyngeal-sphincter" in cases afflicted with split velum. D.—Note how the "palato-pharyngeal-sphincter" is restored when the sutures are applied in the "push-back operation" performed in cases with split velum.

insure success. This idea was subscribed to by Skey, in 1851, and Pollock, in 1856, who divided the muscle proper. Agnew, in 1860, Warren, in 1863, and Schuh, in 1863, advocated section of the tendon of this muscle. In 1868, Whitehead advised division of the hamular process and the muscle. In 1889, Billroth suggested breaking off the mesial pterygoid plate in order to release the lateral pull of the tensor palati muscle.

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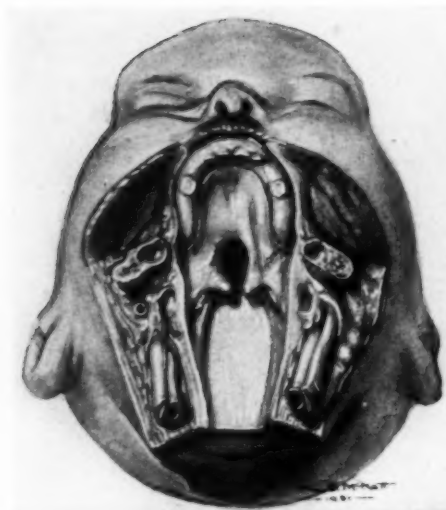
FIG. 13.

FIG. 14.

FIG. 13.—Shows the relaxation incision applied in the first stage of the "push-back operation."
FIG. 14.—Shows how the palatine mucoperiosteum is raised from the underlying bone all the way back
to the attachment of the palatine aponeurosis.
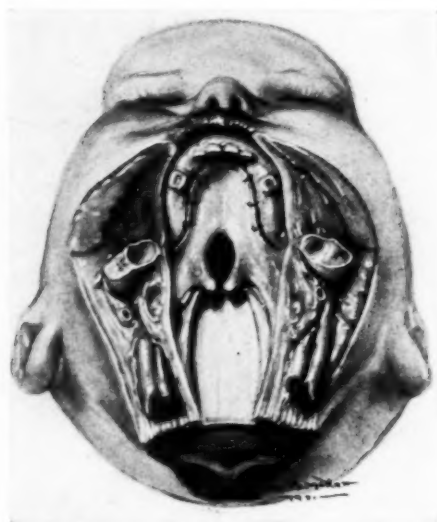
FIG. 15.—Shows the end of the first stage
in a "push-back operation" performed for a
cleft velum. The raised palatine mucoperios-
teum is held in position with silk sutures.
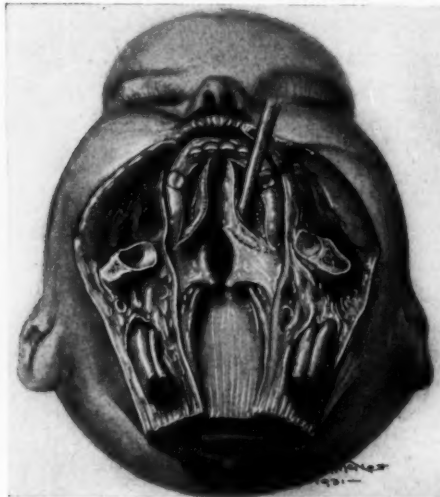
FIG. 16.

FIG. 17.

FIG. 16.—Depicts the lateral incisions applied in cases in which the palate has no adequate blood supply. Note the anterior bridge of attachment for nourishing the flap until collateral circulation is established.

FIG. 17.—Shows how the palatine mucoperiosteum is elevated when lateral incisions are applied.

FIG. 18.
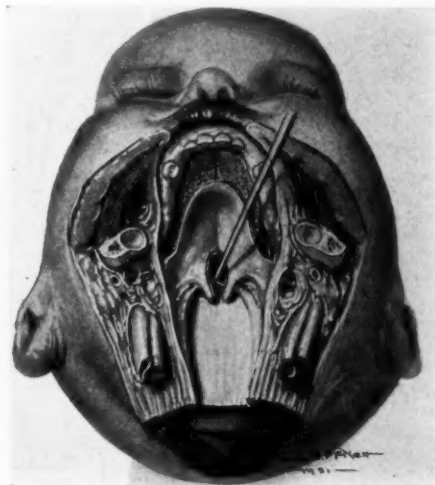
FIG. 19.

FIG. 18.—Shows the second stage of the "push-back operation." The palatal mucoperiosteum has been completely freed from the underlying bone and the nasal mucosa divided from its connection with the posterior border of the hard palate. The hamular process is also sectioned above its connection with the mesial pterygoid plate.

FIG. 19.—Shows the displaced palate completely freed. Note how the ends of the relaxation incision are extended over the pterygomandibular fold. The borders of the cleft velum are also freshened.

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The raison d'être of our method of operating for cleft palate is to restore the velum and place it in a normal or in an approximately normal position so that the resultant velopharyngeal closure will adequately shut off the naso-pharynx and enable the patient to speak distinctly. With this object in view, we usually perform a two-stage operation. In the first of these proceedings the necessary relaxation incision (Fig. 13) is applied so as to raise the pala-
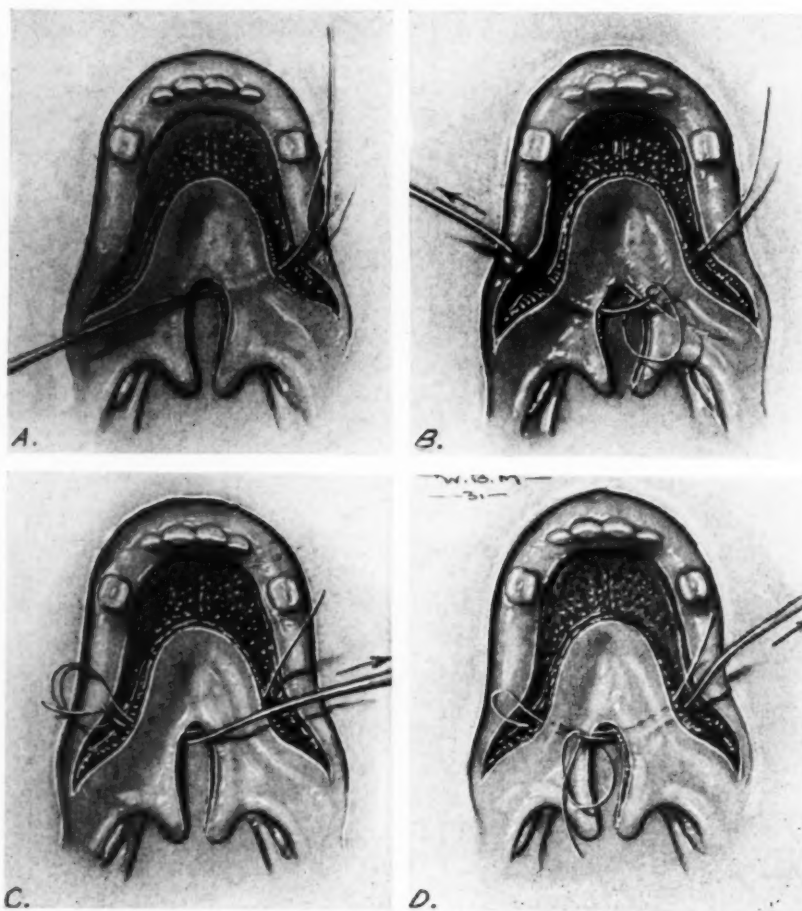
FIG. 20.—Depict the placing of the aluminum-bronze suture through the muscle tissues. This suture was first used by Dr. Victor Veau.

tine mucoperiosteum from before backward by dissecting it from the under-lying bone with suitable elevators. (Fig. 14.)

The posterior palatine arteries are divided as the palatine mucoperiosteum is freed from its bed all the way back to the attachment of the palatine aponeurosis. When this is completed, the flap is replaced in its original position and held with sutures. (Fig. 15.) At times, especially in cases in which the palatal tissue is delicate, a lateral incision is applied on each side, leaving for the flap an anterior bridge of connection behind the incisor teeth. (Figs. 16 and 17.) This bridge is divided in the second stage of the operation. From three to six weeks later, when the collateral circulation is established,
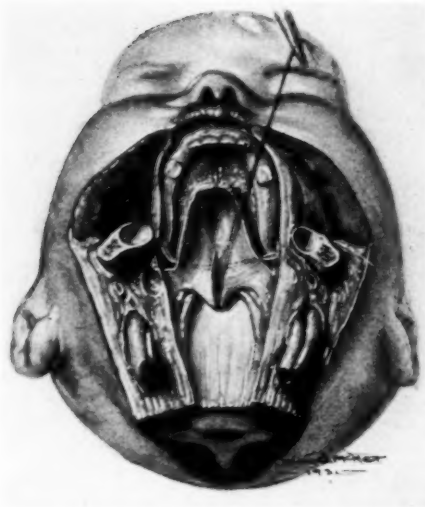
FIG. 21.—Show the intramuscular wire suture in place and the silk coaptation sutures in the nasal mucous membrane.

FIG. 22.

FIG. 23.

FIG. 22.—The cleft palate completely closed at the end of the "push-back operation." Note the wire support applied across the palate and around the maxillary teeth to hold the displaced palate upward against the bone.

FIG. 23.—The healed palate after the "push-back operation." Note that the denuded bone has completely filled with granulation tissue. The cleft anterior segment of the pharyngeal ring has been restored, thereby restituting the split "palato-pharyngeal-sphincter."
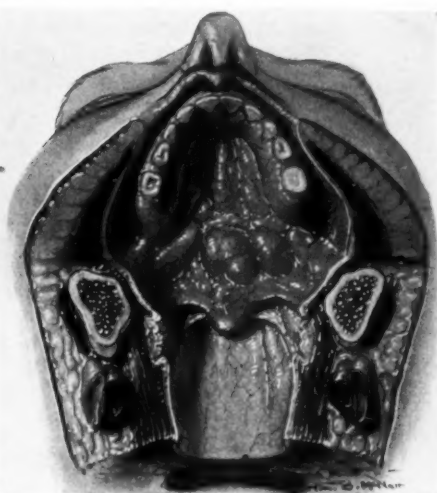
FIG. 24.   FIG. 25.

FIG. 24.—An adult female patient with submucous cleft palate. Note extensive absence of bone from the median palatine region. The palatine mucous membrane is intact. The "palato-pharyngeal-sphincter" is too wide to close the nasopharynx. The anterior segment of this sphincter is also cleft due to a submucous cleft in the muscle tissue.

FIG. 25.—The same adult female patient with submucous cleft palate after the "push-back operation." Note how the palate lengthened thereby narrowing the nasopharynx. The "palato-pharyngeal-sphincter" can now function properly.
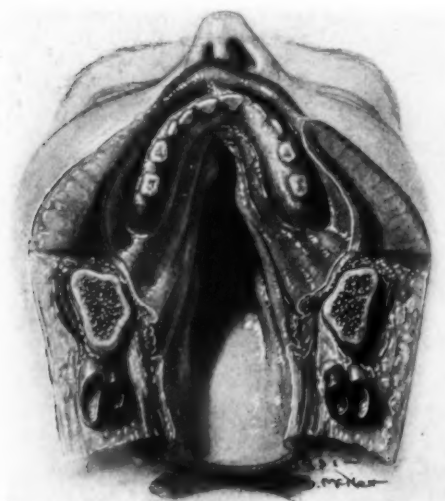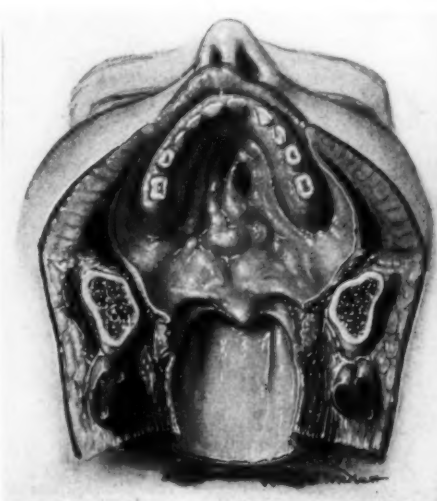
FIG. 26.   FIG. 27.

FIG. 26.—View of the palate of an adult female as she came to our clinic seeking treatment. This patient was operated upon previously with failure. Note how the velum is lost into the lateral walls of the pharynx due to previous operative interference.

FIG. 27.—The same patient after the "push-back operation." Note the way the palate has been lengthened, thereby enabling the "palato-pharyngeal-sphincter" to close the nasopharynx. The holes in the anterior portion of the hard palate will close after cauterization. If these holes persist they can easily be covered with a plate made of vulcanite.

a condition determined by the color of the flap, the final procedure is instituted. The mucoperiosteum is again elevated and the palatine aponeurosis and nasal mucous membrane freed from their connection with the posterior border of the hard palate. (Fig. 18.) The hamular process is divided by means of a chisel on either side above its attachment to the mesial pterygoid plate. In all cases, it is necessary to extend the relaxation incision backward around the tuberosity and over the pterygomandibular fold to obtain sufficient mesial displacement of the muscular tissue. (Fig. 19.)

When the tension is freed, the two halves of the cleft meet easily in the mid-line, the velum will be in contact with the pharyngeal wall and when the sutures are subsequently applied, the pharyngeal sphincter will be restored.

The next step is to freshen the borders of the cleft and insert interrupted sutures in the nasal mucous membrane; the ends of these sutures are left long and are not tied until the insertion of the intramuscular wire suture which was first suggested by Dr. Victor Veau.

An aluminum-bronze suture is placed into the muscles—this we accomplish as follows: A Reverdin needle is introduced into the muscular tissue through the right relaxation incision (A Fig. 20) and gently pushed through until it emerges at the mid-line of the right flap. The wire is passed through the eye of the needle and is dragged through the muscle by withdrawing the needle until one inch or more emerges at the right relaxation incision. The needle is now inserted into the muscular tissue through the left relaxation incision at a point opposite the place of exit of the wire from the previous step. (B Fig. 20.) As the point of the needle is seen in the cleft the end of the wire suture is picked up and drawn through the muscle. When the needle is withdrawn, the wire suture emerges at the left relaxation incision. The needle is now inserted in the mesial portion of the left flap about one quarter of an inch below the wire which lies across the mid-line and pushed intramuscularly through the left flap so as to emerge again in the left relaxation incision. (C Fig. 20.) The wire is passed through the eye of the needle, which is now withdrawn. The needle is again inserted in the right relaxation incision and pushed intramuscularly through the right flap towards the mid-line where the end of the wire is picked up in order to withdraw it to the right relaxation incision. (D Fig. 20.) A study of the diagram will show the placing of the wire suture and will make the procedure much more easily understood.

The interrupted sutures placed in the nasal mucous membrane are now tied. (Fig. 21.) The two ends of the wire suture, passed through the muscular tissue, are twisted together to bring the flaps in apposition at the mid-line. The oral mucous membrane is united with coaptation sutures. (Fig. 22.) The anterior extremity of the displaced palate is held against the denuded palatine vault with sutures passed through the bone; a further support is obtained by passing a heavy piece of silver wire behind the premolar or one of the molar teeth, then across the palate and behind the same teeth of the opposite side using wire of sufficient length so that the two ends can be molded around the dental arch meeting in front of the incisor teeth where the ends are twisted together and turned back over the incisors. An iodoform gauze pack is then placed between the wire splint and the united palate so as to support it. This gauze pack is changed after four days. The denuded bone and gaps formed at the site of the relaxation incision close with granulation tissue. (Fig. 23.)

In dealing with cases of lip-jaw-palate splits, in which the soft tissue is of adequate length, a modified von Langenbeck procedure is performed. In brief—this modification consists of releasing the tension produced by the tensor palati muscles and extending the relaxation incision over the pterygomandibular fold, the application of the muscle suture and the use of the two-stage procedure whenever we find that the palate has not an adequate blood supply.

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The "push-back operation" is used in cases with congenital shortening of the palate, cleft velum and cleft palate which extends as far forward as the anterior palatine foramen. In these cases, the operation ends with complete restoration of the palate. It is likewise applicable in cases of complete cleft palate in which the velum is short and the von Langenbeck operation cannot insure success. Here there occurs a defect in the anterior portion of the hard palate for which we advise an obturator-plate to which may be attached all the teeth missing from the upper jaw. We have found the "push-back operation" invaluable in reclaiming the palates of individuals in whom the usual cleft-palate operation has ended with operative and functional failure.

The age of choice for cleft-palate operations is always a matter for discussion. It is our opinion, as to this point, each case of cleft palate is a law unto itself, the decision as to the proper time to operate being influenced by such factors as the general health of the child, the type and extent of the deformity and the character of the tissue. When conditions are favorable, we usually operate between the second and fifth year. In our experience, operations performed after the fourth year are free from mortality and the failures are less frequent.

From a study of our follow-up of cases of cleft palate and the cases that came to our clinic after having been operated upon by other surgeons, we are convinced that where no shortening of the velum exists good operative and functional results may be obtained in the hands of skilful operators by any of the classical cleft-palate operations.

From the patient's standpoint, any operation on the palate is judged by the functional speech obtained following operative interference regardless of the opinion of the operator.

Speech training will do much towards improving the patient's speech habits, but in a broad general way the more satisfactorily the palate is restored to establish a proper velopharyngeal sphincter the less necessity there will be for speech training.

Figs. 24 and 25 show a case of congenital shortening of the palate before and after the performance of the "push-back operation"; while Figs. 26 and 27 present a case of cleft palate which has been satisfactorily closed by the "push-back operation." The patient whose palate is depicted in Figs. 26 and 27 was previously operated upon before coming to our clinic by the von Langenbeck operation which terminated with failure.

THE PRE-OPERATIVE AND POST-OPERATIVE CARE OF CONGENITAL CLEFTS OF THE LIP AND PALATE

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The pre-operative and the post-operative care of patients with congenital clefts of the lip and palate is of considerable importance. The age of the patient and the location of the field of operation materially increase the operative risk. The mortality rate in children under two years of age has been frequently emphasized and every precaution which can be taken to lower this rate is well worth the trouble. I feel that this can best be accomplished by suitable pre-operative preparation, skillful operative work, and well-directed post-operative care.

For several years it has been my privilege to have a good deal to do with the cases of congenital clefts of the lip and palate in the service of Dr. John Staige Davis, at the Union Memorial Hospital. Inasmuch as the methods he uses in the pre-operative and post-operative care have been very satisfactory both in his cases and in my own, it occurred to me that an outline of the routine used in preparing these patients for operation and in caring for them after operation might be useful and interesting.

No surgeon should undertake the repair of congenital clefts of the lip and palate who has not had sufficient special training to assure a fairly rapid and skillful piece of work. After seeing the results of failures in other clinics I feel strongly that no one is justified in doing what may become irreparable damage to the patient because he is not thoroughly familiar with the necessary procedure. The repair of the lip or of the palate should not take much over an hour in ordinary cases.

There is still some difference of opinion as to the best time to correct these defects. We are convinced that the cleft lip should be repaired as soon after birth as is possible, depending upon the nutrition and the vitality of the child. The general condition of the patient is of prime importance and one should not be rushed into operating because the "new-born are immune to shock," or because "no mother should see her baby with a cleft lip." The closure of the lip can be delayed until some time before the end of the third month, or even longer if necessary, the most favorable time being within the first six weeks.

We have found that the best time for the repair of the cleft palate is between eighteen months and two years. The tissues have developed sufficiently by that time to be easily handled and will hold sutures without tearing. The earlier closure of an accompanying cleft of the lip will usually bring the margins of the alveolar cleft close together and will probably definitely narrow the palate cleft. The closure of the palate should not be

delayed longer than two years, unless absolutely necessary, because the time for speech development has arrived and the patient should be spared the difficulties of relearning to articulate.

We feel that the pre-operative and the post-operative care determine to a very great extent the percentage of success and failure and probably have also much to do with the mortality. The cause of death is usually broncho-pneumonia or gastroenteritis, and occasionally a child will die upon the operating table from the anæsthetic. In a large series of cases under two years of age Doctor Davis has had one death which occurred upon the operating table from ether anæsthesia. More than half of these cases were operated upon twice before they were two years of age—once in the early months for the lip, and later for the repair of the palate. Reports in the literature give a mortality rate ranging from 1 to 8 per cent.[1] on patients under two years of age.

I shall consider the pre-operative care of the patients to be operated upon for cleft lips and cleft palates separately as they present somewhat different problems.

If the patient with a cleft lip is in poor condition we advise admission to the hospital as soon after birth as possible. No date is set for the operation and the family is told that it will be performed as soon as the baby is fit. However, if there is an attending pediatrician, the child is left in his care until he is sure that operation can be safely risked, which is usually about the time when normal birth weight is reached. Then the patient is admitted, preferably forty-eight hours before operation.

The dietetics of these little patients is always a problem which must be solved before any operative treatment is attempted. Because of the inability to suckle they are usually fed with a spoon or medicine dropper, and a great deal of air is swallowed with the feedings, which tends to insufficient nourishment. They often fail to do well if fed on improper formulas and gastro-intestinal disturbances frequently follow which may be difficult to correct. However, if a satisfactory formula is developed by the outside pediatrician, we follow it after the child is admitted, at least well on into the convalescence.

The feedings of the patients admitted to the hospital are worked out by the pediatrician in charge, under whose dietetic care they remain until discharged from the hospital. Feedings are given by means of glass syringes with large openings in the nozzles to permit the free flow of milk and also to permit the feeding of concentrated foods if necessary. The syringes used are similar to the ordinary Dakin's syringes with blunt points. If a sharp-pointed syringe is used the nozzle is capped with a piece of rubber tubing to prevent accidents. After each feeding the mouth is carefully cleansed with boric solution. Because this method has been entirely satisfactory we have not used any of the complicated dams or other apparatus devised for feeding children with cleft lips. No operative work is done until the patient is gaining weight satisfactorily, excepting in an occasional case when, despite every effort, the patient fails to thrive. In these cases an operation must be

risked after the pediatrician has assured himself that the trouble lies in the gastro-intestinal tract and that further delay might be dangerous. These children frequently will begin to improve as soon as the lip is closed.

In addition to milk, patients are given orange juice with cane sugar twice daily and sodium bicarbonate in proper dosage three times daily as this tends to lessen the possibility of acidosis after operation.

In the meantime, the patient is given a careful physical examination. Special history sheets[2, 3] are used for recording the history and the physical examination. The house officer in charge fills in answers to all the questions on the sheet and marks in with red ink the type of cleft of the lip, or palate, or both, upon the marginal diagrams. This method makes the histories valuable for future study since fairly complete data are thus secured in every case.

The Wassermann reaction, hæmoglobin, bleeding time and clotting time of the blood are secured. We do not operate if the hæmoglobin is below 70 per cent. and prefer to have it above 80 per cent. if possible. The bleeding time and the clotting time should be normal. If these are prolonged, calcium lactate is given in doses appropriate to the age of the patient. If jaundice is present the operation is delayed until it clears up, everything else being satisfactory.

The patient is given daily exposures under the violet-ray lamp beginning with one minute, the patient being thirty inches from the light, and the time being increased one minute daily until the daily exposure is five minutes. The eyes are protected by dark goggles and the entire body is exposed. The reaction of the patient is watched and the exposures decreased in time or frequency if necessary. We feel that this treatment probably has a beneficial effect upon the hæmoglobin.

Transfusions of whole blood are given when the condition of a patient is very poor or if the hæmoglobin fails to respond to ordinary treatment.

If syphilis is found, which is quite rare in our experience, operation is deferred until treatment has been started and the treatments are continued after operation as long as necessary.

There is a pronounced tendency to respiratory diseases in congenital clefts of the lip and palate because of the inrushing of air which has not been warmed and cleansed by a normal passage through the nose and because of the inhaling of fluids while feeding. Some surgeons feel that these patients should not be operated upon during the fall and winter months when the air is cold and respiratory diseases most prevalent. However, if the patient is hospitalized in a protected cubicle for a sufficient time before operation this objection is minimized and we do not hesitate to operate at any time of the year after adequate preparation. Two drops of 20 per cent. argyrol are put into each nostril three times daily while the patient is waiting for operation. No patient is operated upon who has any rise in temperature for forty-eight hours before operation.

The presence of an enlarged thymus gland is frequently stressed as an important factor in the mortality rate. Some surgeons have their patients

routinely X-rayed to determine the condition of the thymus gland before operating. If the thymus is enlarged X-ray treatments are given until its size is reduced. One or two exposures have only a passing effect upon the gland and numerous exposures have a tendency to cause fibrosis of the lungs, which may possibly result in pulmonary ailments later in life. We have not given the presence of an enlarged thymus gland found on physical examination any special consideration and do not have routine X-rays taken. We have had, as yet, no untoward results and feel that the danger can be minimized by skillfully given anæsthesia.

The urine is examined for albumen, sugar, acetone, pus and casts. Any abnormal condition found is treated.

The preparation of the patient takes from a few days to several weeks, depending upon the condition on admission. After the child has become acclimated and adjusted to the routine of the nursery and has been taught to take its food through a syringe, the preparation is complete if all other conditions are favorable. This preparation is well worth while as a very young child can hardly be expected to survive if it has a serious operation added to dietetic or respiratory troubles which have sapped the little vitality it possessed.

The pre-operative care of a patient for a cleft palate operation is slightly different because the patient is older. As mentioned previously, we feel that the best time for repairing congenital clefts of the palate is between eighteen months and two years. In many instances, the patient has been under our care before when the cleft lip was repaired and the parents were instructed concerning feedings when the patient left the hospital. Upon readmission the parents are questioned concerning the diet of the patient and the gain in weight. If the pediatrician feels that the child has done well no attempt is made to change the type of feeding before operation, even though it may not be scientifically suitable for a child of that age. An immediate change of diet in these cases would cause unnecessary delay since it would be unwise to operate until the patient had been found to be gaining weight upon the new diet. In the ward the child is given orange juice with cane sugar twice daily and sodium bicarbonate three times daily in doses appropriate to its age. Two drops of 20 per cent. argyrol are put into each nostril three times daily.

The blood and urine are examined as described above. If the hæmoglobin is found to be low, the patient is given cod-liver oil and syrup of the iodide of iron in addition to violet rays.

The past history of these patients is investigated to ascertain whether there has been any exanthematous disease, respiratory disease, or ear infections. There should be an interval of three months between the last disease and the operation. If the examination of the throat reveals infected tonsils and adenoids a tonsillectomy and adenoidectomy are done and in a few days the patient sent home for at least three and preferably six months. The presence of infected tonsils and adenoids militates against

primary healing and one is not justified in taking a chance where tissues are so scant and secondary repairs extremely difficult. The interval of time permits the area to heal well and the scars to soften so that the soft palate can be more easily repaired.

Parents are instructed to have all decayed teeth taken care of by a dentist before bringing the child for operation. These precautions are taken to remove any foci of infection from the mouth which might jeopardize healing.

The average uncomplicated case is operated upon within forty-eight hours after admission to the hospital. However, if anything abnormal is found, the operation is delayed until such time as the pediatrician feels that the child is a good risk.

Food is given both lip and palate patients until eight hours before operation and water is given until they are sent to the operating room. No drugs or sedatives are given pre-operatively to the children under two years of age. Atropin is sometimes given older children and frequently avertin is used in small doses to eliminate the fear and anxiety caused by the preparation for operation and the initial anæsthesia. The children are brought to the anæsthetizing room in their own beds. Ether is given by the drop method until the patient is in the secondary stage, at which time he is wheeled into the operating room. The anæsthetist should always be experienced as these anæsthesias are difficult. The anæsthetic is usually given through a spray or through the attachment on the tongue depressor of a S. G. Davis mouth gag.

The patient is secured upon the operating table in such a manner that the head can be lowered into the lap of the operator. We feel that this position gives the operator the best view of the operative field and makes the aspiration of blood and mucus into the lungs less likely. We try at all times to keep the anæsthesia so light that the reflexes are not lost. An assistant keeps the throat clear of blood and mucus by means of a suction apparatus. The entire time of anæsthesia is usually kept below one hour and a quarter and the operative time is usually about one hour.

After the operation on the lip is finished the skin is wiped clean and the suture line is painted with third strength iodine and over this evaporated compound tincture of benzoin is applied. The iodine is one third of the standard pharmaceutical strength and the benzoin has been evaporated to the consistency of thin molasses. No other dressings or appliances are used in the lip cases. After the palate operations the suture line and the lateral incisions are painted with 20 per cent. argyrol which is also dropped into the nostrils. All bleeding should be checked as carefully as possible before the patient leaves the operating room. Iodoform gauze packs are placed in the lateral relaxation incisions after the palate operations if there is any oozing. No apparatus or plates of any kind are used to support the stitches in these cases as we feel that they are hard to keep clean and are a hindrance to good healing. A small split rubber tube is placed in the nostril on the operated side after the lip has been repaired to aid the patient in breathing and to help to shape the nostril. We consider that the light anæsthesia prevents

aspiration pneumonia and is well worth while even though it makes operating a little more difficult because the patient may move.

The tissues of both the lip and palate are handled as gently as possible during the operation to avoid any unnecessary trauma. All lip and palate flaps are thoroughly mobilized. Dural hooks are used instead of thumb forceps whenever possible and clamps are never put on the margins of lip or palate flaps to stop bleeding or to act as retractors. The skin surface of the lip and the vermilion border are always closed with horsehair, silk being used in the mucus membrane. The palate flaps are closed entirely with horsehair sutures, which are easily kept clean, because mucus and milk do not adhere to them as to silk and so are a great advantage in the post-operative care. Horsehair also has the advantage of some elasticity, which permits post-operative swelling of the sutured parts without causing necrosis at the points where the sutures are placed, thereby preparing an entry for infection. We feel that the stiff ends of the tied horsehair tend to keep the tongue away from the palate and are an advantage even though they may cause some temporary discomfort.

The patients are placed in their own beds, which have been carefully warmed, directly from the table in the operating room, thus eliminating unnecessary exposure and handling. Patients operated upon for cleft palates are placed upon their abdomens with the heads turned to one side, so that mucus or blood can easily run out of the corner of the mouth. A nurse is in constant attendance until consciousness returns so that no accidents may occur because of difficulty with breathing, especially after cleft-lip operations where the lower lip may act as a valve and prevent satisfactory interchange of air. Codeine sulphate is given hypodermically to patients operated upon for cleft palates in sufficient amounts to keep them comfortable and quiet. Paregoric is given to patients operated upon for cleft lips. We try to prevent crying as much as possible.

The palate cases are not given anything by mouth for twenty-four hours after operation. The cleft lip cases are given sterile water as soon as they can swallow and sterile feedings are resumed four hours after operation.

All cases are given proctoclysis every four hours until they are taking fluids satisfactorily by mouth. This is particularly necessary in the palate cases which are kept from any fluids by mouth for the first twenty-four hours after operation. The solution used is made up of one gram of sodium bicarbonate and one cubic centimetre of commercial glucose to fifty cubic centimetres of water. A child of two months receives fifty cubic centimetres per dose and the dosage is increased according to the age or decreased according to the patient's ability to retain it. The proctoclysis tends to prevent acidosis and supplies necessary fluids.

Palate cases are given sterile fluids by mouth after the first twenty-four hours. The suture line is carefully cleansed with boric solution after each feeding and swabbed gently with 20 per cent. argyrol solution. Two drops of 20 per cent. argyrol are dropped into each nostril three times daily. In

the cleft lip cases the mouth is kept clean with boric solution and the suture line under the lip is painted with 20 per cent. argyrol after each feeding.

The patients are restrained by means of cuffs placed over the elbows. These are made of cardboard covered with muslin and prevent the children from touching their lips and mouths. The legs are restrained by means of loose muslin cuffs on restraining straps fastened to the beds. These permit the children to lie comfortably but prevent them from rolling upon their faces. After the tenth day the palate cases are given a very soft diet of cooked cereals, soft-boiled eggs, custards, and so on.

The compound tincture of benzoin dressing on the lip is softened with boric ointment applied twice daily after the fourth day. The stitches in the skin surface and the vermilion border of the lip are gradually removed from the fifth to the eighth days after operation. The sutures in the mucous membrane of the under side of the lip are removed on the tenth to the thirteenth days after operation. The sutures in the palates are removed on the thirteenth and fourteenth days after operation. We very rarely find it necessary to anæsthetize a patient to remove sutures from the palate or from the under side of the lip. Patience and a little care will suffice without doing any damage to the lip or palate.

When the patient is discharged from the hospital the parents are instructed to massage and stretch the repaired lip for a few minutes each day over a period of at least six months.

The scope of this paper does not include speech training which is a necessary further step in the after-care of many of the palate cases.

In this series of cases I have never seen the suture line in the lip break down or separate. In the palate cases none have broken down completely, but in a few, where the flaps have been very thin, there has been partial separation of the suture line. Occasionally, infection will attack the edges of the palate flaps, causing a very narrow grayish slough along the margins which prevents healing. So far we have been unable to check this type of infection, which fortunately is rare. These post-operative palate defects can be closed by secondary operation not sooner than six months after the first operation.

The pre-operative building up of poor surgical risks and the post-operative care of cleft lip and palate patients require ceaseless vigilance and the most exacting and conscientious type of nursing. The care of these patients requires special training of the nurses, upon whom the result depends probably more than it does upon the surgeon. We are particularly fortunate in having head nurses in the Johnson ward of the Union Memorial Hospital who are interested in these cases and enthusiastically supervise the work of the undergraduate nurses.

SUMMARY

(1) Operations for the repair of congenital clefts of the lip and palate, except in rare cases, should never be undertaken until the patients are in the best possible physical condition.

(2) The pre-operative and post-operative care of these patients should be in the hands of a pediatrician working with the surgeon.

(3) The repair of congenital clefts of the lip and palate should be done only by surgeons with special training.

(4) The success or failure of the operative work depends largely on the skill of the nursing staff in carrying out post-operative orders.

(5) The mortality rate should be as low as 1 per cent., if at all necessary.

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TRANSTHORACIC, EXTRAPLEURAL THORACOTOMY *

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DURING the World War, a great number of combined abdomino-thoracic wounds were encountered and it did not take long for Field or Evacuation Hospital surgeons to discover that, in a majority of transdiaphragmatic wounds, the abdominal lesion was best reached and treated via the thoracic route. This was especially true of wounds involving the liver, spleen, cardia and lesser curvature of the stomach; sometimes even the transverse colon. In civil surgery the best approach to the subdiaphragmatic region has been found to be via the thorax, but, with rare exceptions, the transpleural route is still adhered to, involving as it necessarily must do danger of pleuro-pulmonary infection. Perusal of the latest editions of many of our text-books on general surgery sustains this statement.

In vol. ii of Abdominal Operations, Sir Berkely Moynihan, writing of operations on the liver, states that this organ may be reached through a posterior incision along the eighth or ninth ribs, the pleural cavity being either traversed or avoided; in the latter case the pleura is lifted upwards out of the way. In the treatment of hepatic abscess he also states that: "If one or more ribs are to be resected in order to obtain access to the pus, the incision must be made so low down on the chest wall that the pleura is not likely to be opened. As a rule this is avoided by keeping within a limit of two inches from the costal margin. If, however, the abscess has reached a higher level, the pleural cavity will have to be opened."

Gask and Wilson advocate either the abdominal or transpleural route in the treatment of subphrenic abscesses. Ochsner, in Surgical Diagnosis and Treatment, has nothing to say on the subject. McGrath mentions an abdominal and transpleural route, but does not even suggest an extrapleural approach. Horsley advises resecting about two inches of the ninth or tenth rib over the region of the abscess and protecting the pleural cavity by suturing or packing with gauze held in position by a few catgut sitches. In vol. iv of the Précis de Pathologie Chirurgicale, Gosset and Petit-Dutaillis mention the extrapleural resection of Lannelongue, which is described as a chondroplastic or costo-chondroplastic incision by my associate, Dr. P. J. Sarma. This consists in a slightly curved incision from the ensiform process to the anterior end of the bony portion of the tenth rib, passing parallel with the chondral arch, and about 1.5 to 2 centimetres below it. Between the rectus and external oblique muscles on the outer aspect and the internal oblique and transversalis on the inner aspect, the lower border of the costal arch is exposed and can be easily freed. The insertion of the seventh costal cartilage is divided at the sternum and similarly the eighth and ninth costal cartilages are divided just distal to the bony ends of their corresponding ribs, or, if necessary, the ribs themselves are divided just proximal to the costal cartilage attachment. The main objection to the Lannelongue incision—and it is a serious one—is that it destroys the origin of both the external oblique and transversalis muscles as well as the aponeurosis of the external

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oblique. Other subpleural routes mentioned by Sarma are: (*a*) A right-sided transverse lumbar incision, running parallel with the twelfth rib, which is either retracted upwards or subperiosteally excised; (*b*) the intercostal subpleural route in which an incision is made between the lower border of the right tenth rib and upper border of the eleventh, in the mid-axillary line. This incision is below the pleura but gives a very inadequate exposure; (*c*) excision of parts of the tenth and eleventh ribs in the mid-axillary line; (*d*) excision of portions of the seventh and eighth ribs in the antero-lateral aspect of the chest wall, exposure of the pleura and its upward displacement. At this level it is hard not to open the pleura during the necessary blunt dissection. Romanis and Michiner, in vol. ii of Science and Practice of Surgery, state that: "A subphrenic abscess is best opened by removing a portion of the ninth or tenth rib in the mid-axillary line, and incising the diaphragm across the usually obliterated pleural space in the phrenicocostal angle, or, by performing the operation a little lower, the pleura may be avoided altogether and
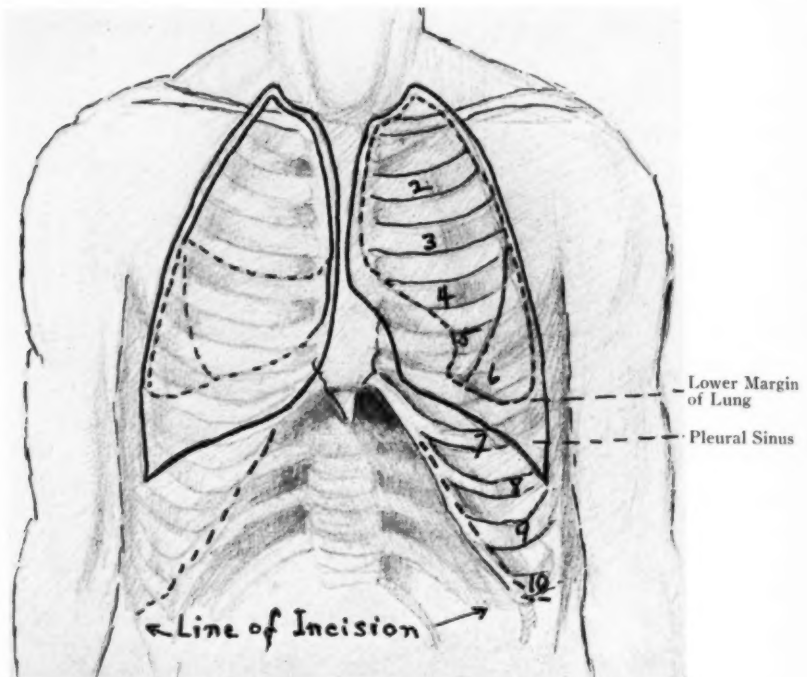
Fig. 1.—Anatomic relationship of lung, pleura and incision.

the diaphragm incised below it. If the abscess is pointing at the abdominal wall it should be opened there, but a transpleural counter-opening is often necessary." Writing on the treatment of amœbic abscess of the liver, the same authors believe that probably the best approach is from the side, with removal of the ninth or tenth ribs, provided it is certain that the pleural cavity is already obliterated. As it is a pre-operative impossibility to know what the condition of the pleural cavity is, this approach will, in a majority of cases, prove to be a transpleural one. Rose and Carless, in their last edition, advocate draining a subphrenic abscess either through the anterior abdominal wall, with or without a counter-opening, or through the pleural cavity. They do add, however, that if the pleural cavity is not affected, the serous membrane covering the upper surface of the diaphragm must be stitched to the parietal pleura before the diaphragm is incised. The same transpleural route is recommended for drainage of a hepatic abscess.

Binnie, in his Operative Surgery, states that: "By the time that a hepatic abscess has become large enough to be diagnosed and its position ascertained, there is almost always adhesive pleuritis present; the liver is adherent to the diaphragm, and the diaphragmatic pleura to the parietal, so that a safe route exists to the pus via the obliterated portion of the pleural cavity. More cases of liver abscess can be reached through the abdomen than through the chest. The pus, in a subphrenic abscess, is reached in practically the same manner as is that in a hepatic abscess." Alton Ochsner has lately enlarged on the original technic of resection of the twelfth rib which he described with Nather in 1923. An incision is made over the twelfth rib to within 4 centimetres of the mid-line posteriorly and the entire rib is removed subperiosteally. The next step is a transverse incision of the musculature below the bed of the resected rib at the level of the first lumbar spinous process which should be marked before the operation." In this way the pleura will certainly be avoided. Careful dissection down to the renal fascia, which is recognized as a smooth, shining, fibrous layer, is now carried out. Beneath this fascia the renal fat can be seen. If a retrocæcal or retroperitoneal abscess is suspected, the skin incision can be extended downward and forward towards the anterior-superior iliac spine, the muscles split and the retrocæcal and retroperitoneal regions explored.

For abscesses situated higher up, Ochsner advocates a blunt separation of the peritoneum from the under surface of the diaphragm. He aspirates the pleural cavity above the diaphragm in those cases in which an empyæma is suspected, or explores the subhepatic space with a Clairmont curved aspirating needle. If an empyæma exists, he drains the pleura above the diaphragm. While probably quite satisfactory in the drainage of a retrocæcal abscess following appendectomy, the Ochsner exposure is too far away from the antero-lateral subphrenic region and unduly exposes the perinephric tissues to infection. It certainly should not be used as a means of approach to an amœbic abscess or ecchinococcus cyst of the liver and would be valueless in the treatment of any combined abdomino-thoracic wound.

That drainage of an abscess should be obtained without breaking through nature's defensive zone and, whenever anatomically possible, without traversing normal serous cavities, is a surgical axiom. Even if the pus is often sterile, it may not be harmless. Moynihan tersely states that "no surgeon is entitled to assume that dirty work of any kind is harmless," and Ochsner correctly affirms that "drainage of any infected area through a non-infected wound or serous cavity violates all surgical principles. The drainage of a subphrenic pyogenic abscess through an uninvolved pleural or peritoneal cavity is as unsurgical as drainage of a pulmonary abscess through an uninvolved pleural cavity."

The objection to practically all of the forementioned incisions is that none of them is universally applicable as a means of access to the subphrenic region from the mid-line anteriorly to the vertebral column posteriorly. This is particularly true in the treatment of diaphragmatic prolapses, erroneously called diaphragmatic herniæ because almost all of them are devoid of peritoneal coverings. As recently as June, 1931, Bettman and Hess, reporting a successful repair of a diaphragmatic prolapse in a nine-months-old child, deliberately opened the pleural cavity. They erroneously state that "the child's pleura was filled with intestines." A diaphragmatic prolapse passes through a weakened portion of the diaphragm (through the left side in 122 cases out of 130 reported by Quénu and Féton), and pushes the pleura upwards without penetrating it. Only in the presence of strangulation will

serous agglutination, necrosis and perforation of the normally closed pleural sac occur. The pleura does not even entirely cover the superior surface of the diaphragm, from which it is readily separated.

Bettman describes the diaphragmatic approach as follows: "The incision started just posterior to the posterior axillary line and followed the ninth interspace to the costal margin and then swept upwards towards the left border of the sternum. Great care was taken to clean the parietal pleura in the ninth interspace so that the pleural cavity could be opened under direct inspection, lest the underlying bowel be injured. After the pleural cavity was opened, a ligature was passed about the ninth rib and another posterior to it. The rib was cut between. The ligatures were then tied so as to control bleeding and the incision into the pleura extended into the eighth interspace. The tenth rib was similarly dealt with. Rib spreaders were inserted and the pleural cavity inspected. A muscle-splitting incision was now made in the left hypochondrium and two fingers of the oper-
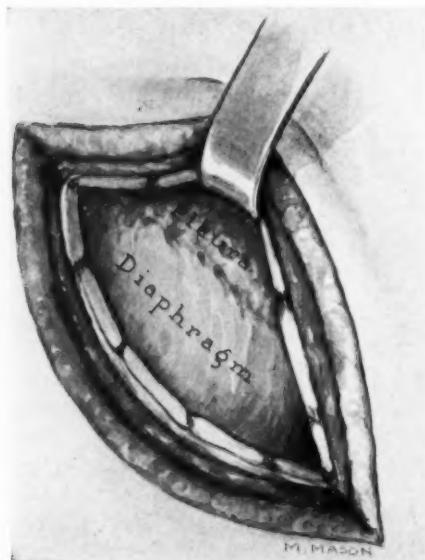
FIG. 2.—Chondroplastic incision, exposing diaphragm and pleural sinus.

FIG. 3.—Diaphragm opened; liver exposed.

ator's right hand introduced into the abdominal cavity up to the hernial opening." There is no argument regarding the advisability of a combined abdomino-thoracic approach in most cases of diaphragmatic prolapse, but the operation would have been greatly simplified had Bettman used the extrapleural approach to the diaphragm.

Surgical Anatomy.—Before making any claims for a new surgical incision it becomes necessary to consider three important operative and post-operative factors, *i.e.*: (1) Will the nerve supply of any of the important muscles or fasciæ involved in the incision be severed; will their main blood supply be jeopardized? (2) Will exposure be adequate and can dependent drainage be obtained? (3) Can firm closure be obtained?

The tissues involved receive their nerve supply from the antero-lateral branches of the seventh to twelfth intercostal nerves and from the ilio-hypogastric and ilio-inguinal branches of the first lumbar nerve. The inter-

costal nerves pass forward in the intercostal spaces to the latter's anterior extremities, when they dip behind the costal cartilages and between the internal oblique and transversalis muscles to the sheath of the rectus which they perforate. The incision which we are describing does not involve the intercostal spaces as it merely severs the fused ends of the eighth, ninth and tenth costal cartilages and free tips of the eleventh and twelfth.

Only minute arterioles of the anterior branches of the intercostal arteries are severed; we have never had to ligate any blood-vessels. The phrenic and costophrenic arteries are not involved. Collateral circulation with branches of the internal mammary and deep epigastric arteries is abundant.

The external oblique muscle origin, by digitations alternating with those of the serratus magnus and latissimus dorsi, is only partially severed, its main attachment being to the costal margin from the seventh costal cartilage backwards. The internal oblique, transversalis and rectus muscles are not interfered with.

The incision may be extended a distance of thirty centimetres; with proper retraction the surgeon's hand penetrates through it quite readily. Dependent drainage is easily obtained, the posterior end of the incision corresponding anatomically to the upper end of the classical lumbar exposure.

Firm closure is obtained because the line of incision severs the costal-cartilages one centimetre from the costal angle. The chondroplastic flap thus obtained enables one to close the diaphragmatic incision, with or without drainage, coapt costal cartilages individually and close the muscles and skin in separate layers.

We believe that the transthoracic extrapleural route fulfils all the desiderata of a paramedian abdominal incision, *i.e.*, avoidance of nerve injury, integrity of muscular origin and insertion, ample exposure and firm closure. With equal facility it can be made on either the right or left side of the anterior median line.

That opening of the pleuræ is always avoided through our incision becomes evident when one considers pleuropulmonary topography.

Antero-laterally, the lower margins of the lungs extend to:

Sixth costal cartilage in the parasternal line;

eighth rib, mid-axillary line;

tenth rib, scapular line. (6-8-10.)

The lower margins of the pleuræ extend to:

Seventh cartilage (lower border), parasternal line;

ninth rib, mid-axillary line;

eleventh rib, scapular line. (7-9-11.)

A thoracic incision beginning at the eighth costal cartilage in the parasternal line and running obliquely downwards, outwards and backwards to the tenth rib in the mid-axillary line and twelfth rib in the scapular line absolutely avoids the pleural sinus. (8-10-12.)

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The pleural sinus is a triangular interval at the base of each pleural cavity, unoccupied by lung tissue. This empty space is about three centimetres high, so that the lower margins of the pleuræ extend the width of one rib below those of the lungs.

The diaphragm has been described as being attached anteriorly to the posterior surface of the xyphoid and internal surfaces of the seventh to twelfth ribs. Together with the pleuræ and lungs it forms a cupola which extends much lower behind than in front.

The Incision.—(1) Identify the eighth costal cartilage in the parasternal line. As a rule its anterior tip blends in with the seventh cartilage but it may reach the sternum directly.

(2) Make an oblique incision from the centre of the eighth cartilage in

FIG. 4.—Left transthoracic incision; approach to spleen.

FIG. 5.—Coaptation of costal cartilages.

the parasternal line downwards, outwards and backwards. The soft tissues and cartilages are severed together; the incision lies one centimetre above the costal angle. An exposure as long as thirty centimetres may thus be obtained.

(3) Retract the costal cartilages upwards and the chondroplastic severed portion downwards. A rib separator of the Tuffier type is useful but not necessary.

(4) By blunt dissection separate the pleural sinus from the dome of the diaphragm and pack in a laparotomy sponge to protect it from the field of operation.

(5) Incise the diaphragm in a line roughly paralleling the costal margin.

(6) Having completed the operation, closure is obtained by suturing each severed cartilage with No. 2 chromic catgut threaded on a curved cutting

needle. The severed sheath of the external oblique and intercostal muscle fibres are coapted by means of interrupted sutures. The skin is sutured separately.

(7) Drainage may be brought out through the posterior angle of the incision or through a still more dependent stab wound.

Variants.—(1) Whenever the clinical history and physical evidence presented enable the surgeon to localize the site of the abscess, only that portion of the incision which lies over the pus should be used. In retrocæcal or retroperitoneal abscesses the posterior third of the incision will be satisfactory; in ecchinococcus cysts of the liver, the anterior third will often give sufficient exposure.

(2) Should an empyæma be found after the chondroplastic incision has been made, the diaphragm is, of course, not to be incised.

Scope of the Extrapleural Incision.—(1) Diaphragmatic prolapses, congenital, idiopathic or traumatic. According to Lenormant and Suter, the thoracic approach to diaphragmatic prolapses of traumatic origin gives a mortality of 5.6 per cent., whereas the abdominal route raises it to 33 per cent. Military surgeons favored a primary thoracotomy in all abdomino-thoracic wounds, only resorting to a thoracolaparotomy when visceral wounds inaccessible by the upper route were encountered.

In non-traumatic diaphragmatic prolapse, if strangulation of the viscus or viscera is present, thoracotomy is the safest route to choose. Of eighteen cases operated upon via the abdominal route, only three survived (Fritsche, Walker, Vieting), whereas the transthoracic route should not give a mortality in excess of 25 per cent. In the absence of strangulation, if the prolapsed viscus is not too adherent, it can be replaced equally well from above or below the diaphragm, but suture of the latter is much easier from above.

(2) Abdominothoracic crushing, stab or gunshot wounds involving the liver or spleen, with or without pulmonary or pleural wounds. World War experience proved beyond cavil that the best method of handling such combined wounds was to enlarge the thoracic wound, if necessary, treat any lesion of lung or pleura and then, by enlarging the diaphragmatic wound, attack from above a wounded liver or spleen.

(3) Sub-diaphragmatic abscesses: Post-appendiceal; amœbic; traumatic; non-dysenteric.

(4) Ecchinococcus cysts of the liver.

(5) Combined supra- and subphrenic abscesses, regardless of their origin.

(6) Splenectomy in non-traumatic cases or in traumatic cases not involving hollow viscera.

CONCLUSIONS.—(1) A simple approach to the diaphragmatic area, evolved as a result of World War experience, is submitted.

(2) It does not involve opening the pleural cavity, gives ample exposure, and its closure is not followed by herniation.

(3) The incision is utilizable either to the left or right of the anterior median line.

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PULMONARY ABSCESS *

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Pulmonary complications following operation are of sufficient frequency to be of interest to every surgeon. Of such complications lung abscess is attended with the highest mortality and a still greater morbidity. During the past fifteen years the incidence of suppurative lung conditions has increased tremendously, attributable doubtless to the greater number of operations done on the upper respiratory tract and also to the influenza epidemics of 1918 and 1927 with the attendant streptococci infections.

The basis of this paper is a study of forty-nine cases of lung abscess occurring during the past seven years. We have excluded from consideration those cavitations due to tuberculosis and bronchiectasis. Likewise, we have not considered those due to the aspiration of a foreign body, nor those due to various types of infection such as actinomycosis, *etc.*, nor pulmonary suppuration resulting from bronchial obstruction due to new growth.

A study of our forty-nine cases reveals the fact that eighteen of them, or 36 per cent., followed some type of surgery. Thirteen cases developed in the course of pneumonia and in twelve cases we could not determine any cause for the pulmonary suppuration. Two cases occurred in blood-stream infections and in these the abscesses were small and multiple and were not discovered until autopsy. Two cases resulted from so-called influenza, one was due to actinomycosis and one to an aspirated foreign body.

As to the sex distribution, thirty-two occurred in males and seventeen in females. This agrees approximately with the usual incidence as given by most writers on the subject.

In those cases occurring as a post-operative complication of the eighteen cases in this group, the abscess was located on the right side twelve times as compared with six times in the left lung. Sixty-six per cent. of these cases occurred between the ages of twenty and forty. The distribution being as follows: Ten to twenty, 2; twenty to thirty, 9; thirty to forty, 3; forty to fifty, 2; fifty plus, 2.

When one considers the number of tonsil operations done on children it is surprising that more cases do not occur in the earlier decade. Such observation leads to the conclusion that it is not the aspiration of blood alone which is the causative factor in the production of pulmonary abscess. Flick, Clerf, *et al.*, in a study of 172 cases of lung abscesses found that 121 followed surgical operations. Of the number, 107 resulted from procedures about the mouth and throat, ninety-seven being tonsillectomies. The remaining fourteen followed other types of operations such as appendectomy, herniotomy,

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* Read before the Southern Surgical Association, December, 1931.

etc. Clerf in a further study of seventy-seven cases following tonsillectomy found that four had been operated under local infiltration and seventy-two under general anæsthesia.

It is our belief that the high incidence of lung abscess in the mid-period of life is probably due to the fact that at that time we find dental infections most common. Children rarely have pyorrhœa or infected teeth, hence the low incidence of the disease in the first decade.

Of the eighteen cases where the abscess followed surgical procedures, seven were due to tonsillectomies and eleven to other types of surgery, one a mastoid, another following drainage of a cervical abscess. In every case a general anæsthetic was employed and in all some ether was given.

There is much controversy as to the route by which the infection gets into the lung—whether per orum by aspiration or through the blood-stream as an embolus. Many experimental studies have been made which show that either mode of infection can and does occur. The result of these various experiments and clinical observations has been well summed up by Kline and Berger of Cleveland from whom the following is quoted:

"The clinical and experimental evidence for embolism is well presented in the excellent communications of Cutler, Schlueter, Weidlein and Holman, and of Fetterolf and Fox. This evidence as presented in a recent communication by Schlueter and Weidlein is as follows:

"Our belief that post-operative lung abscess results from embolism, a mechanism produced by the dislodgment of an infected thrombus from the vessels of the operative area, is based on the following facts:

"(1) The definitely proved existence of the condition of fatal post-operative pulmonary embolism. This supposes the possible scattering from any wound of single or multiple emboli into the venous circulation.

"(2) The frequent development of lung abscess after operations performed in infected or potentially infected fields. In this class we refer particularly to nose and throat operations, especially tonsillectomy, and to operations performed on the gastro-intestinal tract.

"(3) The high percentage of occurrences after operations performed in mobile operative areas. Thrombi are easily dislodged from such regions as the pharynx and epigastrium. In operations on the brain in which the skull acts as a splint the percentage of post-operative pulmonary complications is almost nil.

"(4) The not uncommon appearance after operations in which local anesthesia is employed.

"(5) The failure to prevent post-operative pulmonary complications with the constantly improved methods of giving inhalation anesthesia.

"(6) The greater frequency of lower lobe involvement. This is explained by the greater volume of blood and the more direct course of the pulmonary artery to these lobes.

"(7) The often symptom-free period following the operation before the onset of the complication. If the aspiration mechanism were the causative factor, the appearance of the symptom would be early.

"(8) The sudden pain in the chest that frequently constitutes the initial symptom and the often severe and stormy associated clinical course that often follows before rupture and evacuation occur.

"(9) The acknowledgment by bronchoscopists that typical lung abscess is rare with the lodgment of foreign bodies even deep in the air passages.

"(10) The unsuccessful attempts at experimental production in animals by the introduction of infected materials by way of the air passages, either by transtracheal implantation or by aspiration.

"(11) The comparative ease with which lung abscess can be produced by the intravenous injection of infected materials."

Although pulmonary abscess was produced in dogs by the intravenous injection of a large embolus containing staphylococci, pneumococci and colon bacilli, the process eventuated in healing and not in a progressively enlarging lesion. That such a progressive lesion was not produced is probably due more to the organisms employed than to the route. The experimental abscesses reported by these investigators are similar to the embolic pulmonary abscesses observed clinically in cases of septicemia and pyemia. In cases of this type in man observed at autopsy, the abscesses were invariably multiple, involving several lobes and varying in diameter from several millimeters to about 1.5 centimetres. In one case they were confluent in places. The gross lesions were grayish or reddish gray without appreciable odor. Many were just below the pleura, and this structure was frequently involved. Microscopic examination of sections stained by the Gram method showed clusters of staphylococci first within the lumen of a blood vessel, then within the walls, the lumen at that time usually containing a thrombus. Apparently following the inflammatory process in the walls of the vessel there was a spread of the staphylococci and of the suppurative process into the regional lung tissue.

Although of interest in connection with the evolution of embolic abscess already described, the experiments of Cutler and his associates, in our opinion, do not throw any light on the pathogenesis of the so-called typical lung abscess of man. The following facts are more convincing evidence that in these cases the organisms reach the lung by aspiration:

(1) The frequent occurrence of aspiration of foreign material is borne out by the finding at autopsy of deposits of coal pigment in the lungs of adults.

(2) Pneumonia undoubtedly following the aspiration of food particles and bacteria during the unconsciousness of coma or of anesthesia is an occasional autopsy observation. On microscopic examination, sections from these cases show the foreign material and bacteria in the bronchial branches and in the alveoli, surrounded by inflammatory exudate.

(3) It was reported by Myerson that bronchoscopic observations immediately following tonsillectomy under general anesthesia showed the presence of blood and mucous in the bronchial tree in 155 of 200 cases. Myerson concluded that the failure of evacuation of infected material is the most important factor in the causation of pulmonary abscess. Among the reasons given for this failure are the loss of action of the cilia, the lessened elasticity and compressibility of the lung and a local immobility. Furthermore, it has been shown experimentally that rabbits receiving considerable numbers of pneumococci in the trachea just beyond the larynx get rid of them without suffering appreciable involvement of the lungs, whereas in those animals in which the same number of similar organisms has been introduced into the air sacs an inflammatory process invariably develops.

(4) The production of pneumonia by intrabronchial inoculation of pneumococci in dogs by Meltzer and Lamar, in rabbits by Winternitz and Hirschfelder, and by intratracheal inoculations in monkeys by Cecil and Blake, proved that aspiration can explain the manner in which organisms reach the lung in man.

(5) There is evidence for the belief that the various inflammatory lesions of the lung may be brought about by the aspiration of the causative bacteria from the mouth during the deep sleep following fatigue. In much the same way ether anesthesia increases the opportunity for aspiration into the lung and at the same time renders the body incapable of expelling the foreign material.

(6) The occurrence of severe pulmonary inflammation containing innumerable bacteria following clean operations in clean fields on patients under general anesthesia

indicates that in these cases the bacteria are undoubtedly aspirated from the oral cavity. Likewise, in clean cases done under local anesthesia, the bacteria most certainly reach the lung by aspiration and not by embolism.

(7) An anatomic study, including examination of Gram and Warthin-Starry stained sections of early lesions of pulmonary abscess and of pulmonary gangrene, reveals that the process in these cases is one of inflammation starting in and about small bronchial branches. This is quickly followed, however, by changes characteristic of abscess when staphylococci or other pyogenic organisms predominate in the lesion, and more slowly by changes characteristic of gangrene when spirochetes, fusiform bacilli, and vibrios of the oral type predominate. The spirochetes are present not only in the area of necrosis but also at the advancing periphery.

(8) The experimental production in a rabbit of pulmonary gangrene by the intra-bronchial injection of material from a carious tooth containing innumerable spirochetes and fusiform bacilli is proof that aspiration of those organisms may produce pulmonary gangrene. This experiment is confirmed by those of Smith, who reported the production of experimental aspiratory abscesses in mice, guinea pigs and rabbits by the intra-tracheal inoculation of material from about the teeth of patients with moderately severe pyorrhea, containing spirochetes, fusiform bacilli and vibrios. More recently Crowe and Scarff, and Allen report the production of lung abscess in dogs by the intra-bronchial inoculation of material containing oral spirochetes.

Schlueter and Weidlein state that in a census of recent writers forty declare themselves in favor of aspiration while only ten favor embolism as the direct cause of lung abscess. From the available evidence, the view of the majority is apparently the correct one.

We do not think it necessary to outline the symptoms of pulmonary abscess before this body. As a rule the condition is not diagnosed until the expectoration of a large quantity of foul-smelling pus. The fact should be emphasized of the possibility of the development of pulmonary abscess in every case having pulmonary symptoms after operation. The interval between the time of an operation and the appearance of an abscess is as a rule of short duration and in seven of our cases was from two to nine days. However, it must be borne in mind that the interval may be much longer and in one of our cases it was three weeks, in one four weeks, in one five weeks and in another case the interval between the operation and the development of the abscess was as long as two months.

The diagnosis of lung abscess in the typical case is not difficult but must always be differentiated from tuberculosis, brochiectasis and especially inter-lobar empyema. A carefully taken history together with well-made röntgenograms will in most instances indicate the trouble and a thorough study of the sputum will confirm the diagnosis.

Röntgenograms to be of value in the study of pulmonary lesions should not only be made by the usual stereoscopic method but lateral plates should also be taken. These are of value both from a diagnostic standpoint and as a means of localizing the pathological process. In the X-ray study of suspected lung abscess lipiodol instillation should always be done as by this procedure bronchiectasis can be easily differentiated. On flat anterior-posterior X-ray films the differential diagnosis of interlobar collections of pus from intra-pulmonary pathology may be very difficult. Recently McNeill,

of Louisville, has devised a technic by which the interlobar septa can be well demonstrated. It consists in having the rays pass through the chest parallel with the interlobar spaces. Several cases which we thought were either
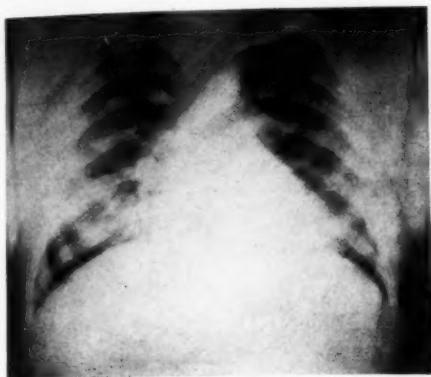
FIG. 1.
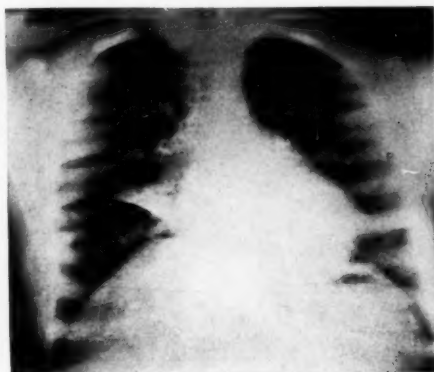
FIG. 2.

FIG. 1.—G. D. Showed haziness in right root with slight, hazy infiltration extending from same in the fourth and fifth interspaces and diagnosed as pneumonitis and suggestion of a hilum pneumonia and bronchiectasis. The fluoroscopic observation in the McNeill tilting position showed definite fluid in the right median interlobar fissure.

FIG. 2.—G. D. Six weeks later showed clearing and absorption of the fluid and interlobar fissure with a residual thickening of interlobar septum and some slight inflammatory reaction extending from the root.

abscess or new growth were by this method of study demonstrated to be interlobar collections.

The aid of the bronchoscopist is most valuable in the study of intra-
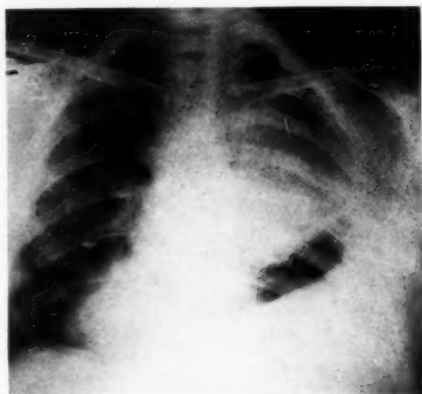
FIG 3.
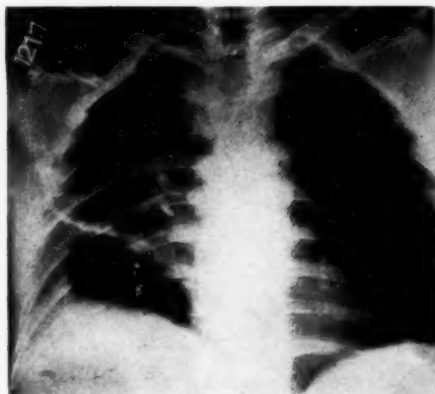
FIG. 4.

FIG. 3.—T. R. Showing unresolved pneumonia three weeks after onset of disease.

FIG. 4.—T. R. Shows cavitation and abscess in area of unresolved pneumonia. (In Fig. 3 the print has been reversed, the disease process being in the right lung.)

pulmonary lesions. By such examination foreign bodies not demonstrated by röntgenographic study may be discovered. Obstructions due to new growths can also be determined by this study. Jones in an article appearing in *The Military Surgeon* cites a case where the diagnosis had been pul-

monary abscess and the true condition, namely bronchial neoplasm, was not even suspected until its presence was demonstrated by bronchoscopy.

Treatment.—Lord has stated that about 10 per cent. of the cases of lung

FIG. 5.
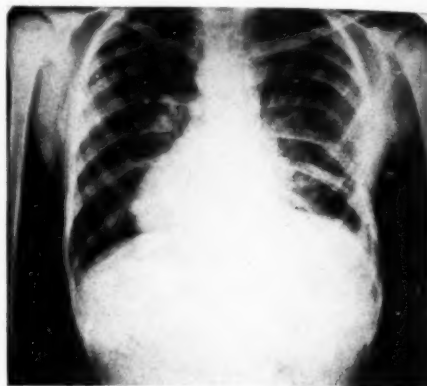
FIG. 6.

FIG. 5.—T. R. End-result six months after external drainage of abscess.
FIG. 6.—R. D., aged nine. Pneumonitis and abscess formation right lung following operation for tonsillitis.

abscess recover spontaneously and Graham puts the percentage somewhat higher. On the other hand the mortality of untreated cases is more than 70 per cent. and the morbidity incident to delay in the institution of treatment is exceedingly high. In the therapy of pulmonary suppuration, as in the

FIG. 7.—R. D. End-result eighteen months after thoracotomy and external drainage.

treatment of tuberculosis, rest, sunlight and proper food is very important. Recovery is obtained only when the abscess cavity is obliterated and this according to Holman depends on drainage, contraction of the fibrous wall and the expansion of healthy lung.

Drainage of the abscess is therefore essential and it can best be in the nonoperative treatment accomplished by socalled "postural drainage" which is obtained by having the patient hang the upper trunk over the edge of the bed with the head dependent, thereby allowing the pus to drain out of the cavity.

In such treatment the position mentioned should be repeated three or four times a day and even more frequently if thought necessary. By this method alone a number of cases will recover and this is particularly true where the abscess is thin walled and not of long standing.

Flick in a study of 172 cases found that 54 per cent. recovered and 13 per cent. improved by bronchoscopic aspiration. By means of the broncho-

scope resultant complicating strictures in the bronchus may at the same time be dilated and exuberant granulation, when present, removed, thus permitting the more certain evacuation of the abscess. This method of treatment is applicable only to those cases where the cavity drains into the larger bronchi near the root of the lung. Moersch in 140 cases observed at the Mayo Clinic found that 105 were treated by bronchoscopy and reported fifty-one recoveries and eighteen improved by this method alone.

Pneumothorax.—Treatment by collapse of the abscess cavity through artificial pneumothorax has only a limited field of usefulness. It should never be done in those cases where the abscess is near the periphery of the lung owing to the danger of rupturing the abscess and producing a pyo-pneumothorax. When the cavitation is near the centre of the lung and communicates freely with a bronchus, the collapse of the lung by the introduction of air into the pleural cavity is a very valuable means of treating this condition.

Phrenicectomy.—Phrenicectomy is employed in the treatment of some abscesses located in the lower lung fields. The rise of the diaphragm following its paralysis may approximate the walls of the abscess cavity and so lead to its obliteration. It must be borne in mind, however, that in cases where the drainage is not free the rise of the diaphragm may cause obstruction to the drainage tract, thereby preventing the evacuation of the abscess and defeating the very purpose of this manœuvre. When such obstruction does occur, instead of improving the patient becomes decidedly worse and so we feel that phrenicectomy should be employed only in very carefully selected cases.

External drainage.—This procedure must be used when the other forms of treatment are without results. When the abscess is situated in the periphery of the lung and bronchoscopic drainage is useless, open drainage of the abscess must be instituted. Miller and Lambert have advised against the institution of external drainage when there is present active acute pneumonitis and it has been our practice not to operate until at least three months after the development of the abscess.

We employ the two-stage method and rarely use tube drainage, thinking it better to open the cavity widely and pack with gauze. Our results have been gratifying and to date we have not had a bronchial fistula. In one case, a post-operative abscess located in the right apex, we did use tube drainage and while this patient was markedly improved and the drainage tract closed she is still having some trouble and we later expect to re-open the cavity widely through an anterior approach.

In the diagnosis and treatment of pulmonary suppurations there should be close coöperation between internist, bronchoscopist, röntgenologist and surgeon. Frequent consultations are necessary and a carefully outlined regimen must be followed. Many cases may be cured without surgery but there is still a large per cent., 25 to 35, which must be operatively drained externally. Furthermore we would emphasize the value of McNeill's X-ray

technic in the differentiation of interlobar from intra-pulmonary pathology. Of the large number of lung abscesses which follow operations, with careful pre-operative attention to infections about the teeth and the mouth many of these abscesses can be prevented.

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PHRENISECTOMY IN THE TREATMENT OF PULMONARY TUBERCULOSIS*

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A mass of literature on this subject already exists, so that it is not necessary to take up time and space with needless repetition of details and theory. It is my purpose in this short article to enter a plea for the early and more frequent use of phrenisectomy. With this idea in view, I have attempted to crystallize here my study of the subject from personal observations in Berlin, Vienna, and Davos, Switzerland, as obtained from the extensive literature available and from my own experience with this operation.

The term phrenisectomy as used in this paper is the operation known as phrenico-exairesis and consists of the evulsion of the phrenic nerve to the length of ten cubic centimetres or more in order to produce a hemidiaphragmatic paralysis on the side of the affected lung.

For the history of this procedure, I refer the reader to any article written on the subject, for all of them are introduced by a historical sketch. The questions of importance here are: How did phrenisectomy come to take the important place that it does today in the treatment of pulmonary tuberculosis? What are its advantages over the other surgical methods in use? What are its dangers, and complications? What are its difficulties from the surgeon's point of view? What is the patient's attitude toward it? I wish to consider these questions especially in the light of comparison of phrenisectomy with other methods in use today.

The actual technic of phrenisectomy may be found in any book on surgery. I wish, however, to mention my preference for the transverse incision, as it leaves a much better cosmetic result; this matter assumes greater importance when the fact is considered that as more and more phrenisectomies are being done the scar will soon label the individual with this malady.

Originally, surgical procedure in pulmonary tuberculosis was applied in this order: First, artificial pneumothorax; second, thoracoplasty; then, thoracocautery; and lastly, phrenisectomy. Soon it was discovered that it was most important for the success of thoracoplasty to do a phrenisectomy first, for the following reasons: To stop the piston action of the diaphragm; to test the function of the other lung before introducing further surgical procedure to produce an improvement in the patient's condition by this minor operation before venturing upon the major procedure of thoracoplasty. Thus it was found that the patient frequently improved to such an extent that thoracoplasty could be omitted. The same happened in relation to thoraco-

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cautery. After a considered Jacobeus operation was abandoned because of extensive adhesions, phrenisectomy was done as an alternative and was soon found to produce the desired effect. As a result, phrenisectomy gradually moved up in order of importance until it stands second only to artificial pneumothorax. It is my object by comparing the two methods to show that phrenisectomy is preferable to artificial pneumothorax even in early cases.

The remarkable improvement in early cases of cavitation after the first artificial pneumothorax is a matter of common observation. In order to maintain that improvement, the artificial pneumothorax has to be repeated and during these frequent repetitions there is a sudden retrogression due to the pulling of adhesions, the formation of fluid, or too much pressure; in other words, the early beneficial effects are spoiled by over-treatment. If, in such cases, phrenisectomy is first performed, it produces the same amount of compression as the early pneumothorax; the improvement in the patient's early condition is as great, and this improvement is usually maintained because there is no gradual loss of compression due to the absorption of air.

The dangers and complications during a phrenisectomy do not present serious obstacles to the method. There is, for instance, the dangers of complications brought about by the failure to recognize the phrenic nerve. This, however, is remote in the hands of a man who has a right to undertake the operation.

There is also a possibility of death from hæmorrhage by the tearing of the pericardiophrenic artery, the transverse scapular, or the subclavian vein. Not an accident of this kind has occurred in my own practice, to Maendl and Schwartzmann in their treatment of 100 cases, or to Wirth and von Jaski, who reported 600, nor in Matson's 300 cases. According to the few reports in the literature of such an accident, when it did occur, the patient was an old person in whom the phrenic nerve was twisted around the subclavian and the vein itself was very sclerotic. In such a case it is highly probable that the fatality was due purely to the sclerosis. The frequency with which an anomalous condition of the phrenic nerve is found in dissection—where it winds around the subclavian vein—would forecast a far more frequent accident to the vein; whereas, as a matter of fact, it is the rarest accident. The relation of the frequency with which only a small section of the nerve can be evulsed during an operation bears a much greater relation to this anomaly, so that we may conclude that the wall of the vein is far stronger than the nerve and that the possibility of rupture of the subclavian is so remote that it may be ignored.

The only other serious dangers are those of injury to the vagus or of air embolism due to injury to the jugular vein. These complications occur only in the presence of tubercular glands or other inflammatory conditions in the neck. In cases of this kind, phrenisectomy should be undertaken with caution.

Minor complications have been reported occasionally, such as extremely rare cases of slight psychic disturbances of very short duration (dyspnœa is

infrequent and transitory) ; extremely rare damage to the thoracic duct; and very uncommon instances of damage to the sympathetic nerve.

On the other hand, complications and dangers in a pneumothorax are apt to occur much more frequently. In the first place, the number of operations on each person is so large that the possibility of accident is ever present. Secondly, the simplicity of its technic lays it open to the temptation of use by incompetent operators, whose name, unfortunately, is legion. Phrenisectomy, on the other hand, is seldom undertaken by medical men, and in the hands of a surgeon is a comparatively simple operation.

Hæmorrhage into the pleural cavity due to injury of the lung tissue or to blood-vessels where adhesions exist is an ever-present menace in artificial pneumothorax. It is also a known fact that in the hands of an inexperienced operator air embolism can easily occur in artificial pneumothorax.

The remote complications in phrenisectomy are almost nil, the exception being occasional gastric disturbances due to the dislocation of the stomach in cases of left-sided phrenisectomy. In artificial pneumothorax there are frequent effusions, which may become purulent; also mediastinal displacements causing embarrassment to the heart.

From the patient's standpoint, the balance is entirely in favor of phrenisectomy. They accept this eagerly in preference to the necessity of repeated treatments by pneumothorax over a period of years, particularly as many of these cases are patients who have to return to work and can ill afford the interruptions for regular refills. Also, phrenisectomy places less strain upon the recently infected other side than does artificial pneumothorax. And it is not surprising that a patient eagerly accepts the idea of a phrenisectomy in preference to the mutilating and deforming operations of a thoracoplastic and to the awe-inspiring thoracocautery.

It is only in cases of hæmoptysis that artificial pneumothorax should be resorted to in preference to phrenisectomy because of its quicker compression.

A big field for phrenisectomy lies in the treatment of bronchiectasis, lung abscess, resistant cases of pleurisy with constant pains and most especially bilateral pulmonary tubercular affections which exclude artificial pneumothorax and thoracoplasty from the start. After phrenisectomy the more seriously affected side conspicuously improves; the less affected side also shows frequent improvement.

In looking over the reports on phrenisectomy we find that the mortality is negligible. In fact, according to the most pessimistic report, there is a mortality of only half of 1 per cent.

Indeed, the general trend of all authors, after weighing all the tried procedures in accordance with their seriousness and importance to the patient, seems to be that the preferred sequence should be: phrenisectomy, artificial pneumothorax if further compression is necessary, and thoracoplasty where artificial pneumothorax cannot add to such required compression.

In conclusion, I want to emphasize early phrenisectomy, which should be considered before artificial pneumothorax is undertaken. Nothing in phreni-

sectomy prevents the institution of pneumothorax later on. In a great many cases the tedious and long-drawn-out pneumothorax treatment will be avoided, especially if one does not lose sight of the fact that tuberculosis is a complex disease, and that other therapeutic measures must not be lost sight of in practising phrenisectomy. I repeat again what I have been emphasizing for the last twenty years. No one therapy can be used in tuberculosis to the exclusion of all others. When a new therapy is discovered, it should be added to our armamentarium and not used to the exclusion of important and still applicable therapeutic measures. Frequently, artificial pneumothorax has to be included in our most successful phrenisectomy. The status of tuberculin is not altered by the most successful phrenisectomy. The use of auto or stock vaccines in mixed infections retains its indication just as strongly after phrenisectomy as before. And the hygienic-dietetic-climatic treatment does not wane in importance in the face of phrenisectomy.

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THE REPAIR OF INTESTINAL FISTULAE

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Intestinal fistulae may be due to: (1) Ulceration due to pressure of tumors or foreign bodies: (2) perforation of ulcer caused by disease processes; (3) intestinal fistulae made intentionally; (4) intestinal fistulae made accidentally (operation); (5) perforating wounds, or contusion of the abdomen with injury to the gut. The fistulous opening may be (1) one in which the mucous membrane of the gut is adherent to the skin; (2) cases in which a fibrous tract or sinus connects the gut with the skin opening;[1] (3) temporary colostomy; (4) cases of fæcal fistula complicated by compound fracture and hemorrhage; (5) cases in which one or more loops of bowel are connected with each other and open by a tract to the skin.

The symptoms produced by intestinal fistulae depend upon the proximity of the fistula to the pyloric sphincter. In fistulas of the duodenum and upper jejunum marked symptoms may be produced in a very short time if the loss of intestinal juices is great. The urea and carbon dioxide content of the blood is greatly increased and the blood chlorides are decreased and death may result. Ehlman and Hartman[2] have shown experimentally that death results because of the loss of gastro-intestinal secretions, and from circulatory and renal insufficiency due to dehydration. The digestive action upon the operative wound may also be a serious complication. A loss of nutritive substances to the body by the escape of the intestinal juices, with resulting emaciation of the patient, presents a very serious situation, so that healing of the wound may be impossible unless the digestive action of the juices can be inhibited and the nutrition and blood chemistry of the patient maintained at normal levels.

This digestive action of the juices is found in fistulae of the small bowel and it may be present, according to Potter,[3] in any part of the intestinal tract in which the intestinal content is liquid. He points to the fact that the pancreatic juices in the chyme prevent the healing of most of these fistulae. That this is true, especially of duodenal fistulae and those of the upper ileum, seems reasonable. In my experience, failure of closure of fistulae in the lower ileum and caecum are due to adhesions of the bowel, tuberculosis, or other disease of the caecum. Fistulae arising from the large bowel are, unless intentional, more often produced by operative or other injury to the bowel and in this series of cases they followed removal of adherent ovarian cysts or were due to inflammatory processes in the pelvis.

The fistulae in the lower bowel, while not so serious from the standpoint of loss of body fluid, are particularly dangerous because of the infective

character of the bowel content, and in their formation they are, as a rule, accompanied by peritonitis of varying degrees of severity. The formation of adhesions due to the peritonitis make closure of fistulae in this area a very formidable one.

This paper will consider the closure of fistulous tracts in which a sinus has already formed, and except for duodenal fistula, will not concern itself with the immediate treatment of the fistula and its subsequent peritoneal involvement.

Duodenal fistula, whether due to operative or other trauma, perforating ulcer or faulty technic in the closure of lesions of the duodenum is a serious condition. The dehydration from loss of intestinal fluids with an alkalosis due to the loss of chlorides from the gastric secretions produces very marked change in a short time. The patient rapidly loses strength and weight. The skin and mucous membranes become dry. The eyeballs become shrunken and glassy, and unless the condition is relieved, death insues in from seven to ten days. The digestion of the tissues about the wound may be so severe that evisceration may take place. Healing is difficult or impossible. The following cases will illustrate this condition.

Case I.—Mrs. E. B., aged forty-two (Fig. 1), entered the Presbyterian Hospital January 21, 1926, with the history of having had an operation for gall-bladder drainage one year before. She gave a history of typical gall-bladder distress, and under ethylene anæsthesia the gall-bladder was removed. The gall-bladder was adherent to the duodenum and the transverse colon, and on dissecting the gall-bladder free, the serosa was torn from the duodenum. The defect of the serosa was repaired, and closure of the abdomen was made with a cigarette drain in the right kidney fossæ. The drain was removed on the fifth day, and on the tenth day there was a small amount of drainage along the tract, so a small rubber drain was inserted. The patient left the hospital after two weeks with the drain still in place. Her husband was instructed to replace the drain if it came out of the tract and two weeks after returning home they reported that on attempting to replace the drain, the patient complained of a great deal of pain, and a short time later they found food material on the dressings.

The patient reëntered the hospital March 30, 1926, for examination. Methylene blue given by mouth appeared in the sinus tract within five minutes, and from the character of the secretions we knew we were dealing with a duodenal fistula. The tract was injected with Beck's paste, but despite our efforts most of the duodenal secretion escaped. The skin about the fistula became excoriated, and the patient rapidly lost weight and strength. Rectal drip of 2 per cent. glucose and hypodermoclysis of normal saline solution were given. Because of the large amount of secretions, an aspirator was used, and the wound kept as dry as possible by this means. Finally a gauze plug was inserted into the fistulous opening and a modified Beck's paste[4] was injected into the tract. The secretions gradually became less in amount and after fourteen days, the fistulous tract was entirely closed. This was corroborated by methylene-blue[5] tests and X-ray findings. The patient has been in comparatively good health ever since, and repeated fluoroscopic examinations have failed to reveal any filling defect as the site of the old fistulous opening.

Case II.—Miss M. F., a nurse, twenty years of age, entered the Presbyterian Hospital, November 26, 1928. Two years previously she had a cholecystotomy, and one year later, because of recurring attacks of pain, the gall-bladder was removed at another hospital. A few days after her operation there was a discharge of food and

biliary fluid from the wound. She was in the hospital for about two months and was discharged with a fistulous opening about the middle of the scar in the right upper quadrant. She had occasional chills and fever and upon entrance to the Presbyterian Hospital she said that during the last few weeks, the discharge had become greater in amount, was bile-stained, and contained food. The skin about the incision was red and excoriated. Methylene blue given by mouth appeared at the fistulous opening in seven minutes. The drainage tube was removed and the fistulous tract was injected with a modified Beck's paste. There was a stoppage of the discharge for about six or seven hours, and on re-injection, the discharge would stop for a similar period. The skin was painted with liquid adhesive plaster, and a gauze plug attached to a tube was
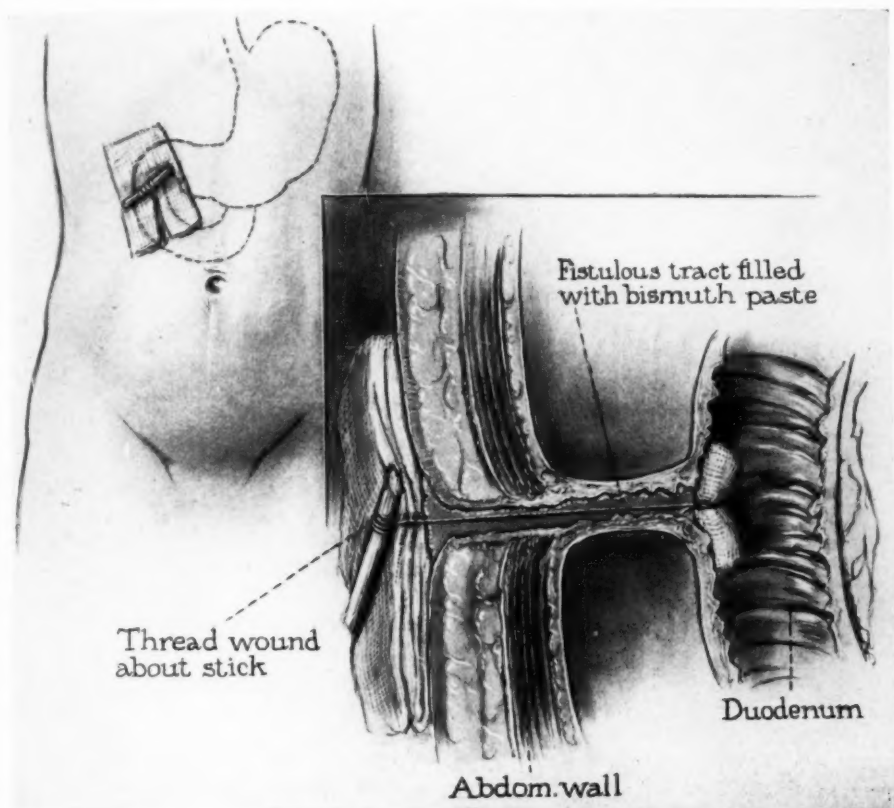
Fig. 1.—Closure of duodenal fistula.

inserted into the fistulous opening and the wound injected with paste. Because of the loss of fluids due to the escape of intestinal content, she was given fluid rectally, and normal saline solution under the skin. There was very little drainage for about five days, after which time there was again a profuse discharge. The treatment was continued, and the patient left the hospital about one month after her admission with the fistulous opening closed. She returned two days later with the fistulous opening again discharging. The discharge was tested and found to contain free hydrochloric acid. The secretion became so profuse that continual suction was tried for three or four days. Because of the great loss of fluids, hypodermoclysis was again instituted. The fistulous opening was again injected with paste and a rubber balloon was inserted in the wound. The rubber balloon, however, caused so much pain, probably due to peristalsis, that it was removed. Modified Beck's paste was continued and three and

one-half months later, the patient was discharged with the wound entirely closed. She returned ten days later complaining of pain and vomiting. There was a slight, almost constant discharge of the fluid from the sinus. She was treated by a modified Sippy diet, and she was advised that operative interference would probably be advisable. Most likely a posterior gastroenterostomy with pyloric occlusion would be done. She left the hospital, went elsewhere where an attempted repair of the duodenal defect was made. The closure was only partially successful and the patient succumbed some months later to a pyæmia, her attending physician reported.

Fistulae involving the ileum, while not so serious from the standpoint of immediate loss of life, are of great concern in that a large part of the digested material is lost. The body fluids suffer and the patients lose weight though not to such a marked degree as in duodenal or jejunal fistulae. Digestion of the tissues about the wound may also be troublesome, and may cause a partial or complete separation of the wound. In this condition, however, the chloride balance may be maintained by giving 2 per cent. sodium chloride solution by mouth, and supplementing it with hypodermoclysis. The intestinal juices that escape can be collected and sometimes re-injected into the lower segment of the bowel. A high carbohydrate diet of a soft non-residue variety will help to maintain the body weight. The fistulous wound can be protected by liquid adhesive plaster applied to the dry skin, while continuous suction of the wound may also be used.

The closure of this type of fistulæ may be spontaneous as, for example, after enterostomy, or as in the following case, operative procedures may be necessary.

CASE III.—W. N., aged eleven (Figs. 2 and 3), entered the Presbyterian Hospital, February, 1931. He had been operated upon one year previously for acute suppurative appendicitis. There had been drainage instituted. A post-operative hernia had formed which had been repaired six months after his appendectomy. He gave a history of having had severe pain in the upper right quadrant followed by profuse vomiting.

He was seen by a physician at the time of the initial attack who advised his parents that he probably had an intestinal obstruction, and they were told to avoid the use of cathartics or sedatives. Later the family physician was called and though enemas, morphine, and castor oil were given, the patient did not improve, and upon entrance to the hospital forty-eight hours later, the patient was practically in a moribund condition. He was unconscious, his skin was cold and clammy, his temperature was 101°, pulse 150, white blood count 18,000, and the abdomen was distended and very rigid.

Under local anæsthesia, an incision was made in the right upper quadrant of the abdomen. Upon incising the peritoneum a large quantity of bloody fluid escaped, and a large gangrenous loop of small intestine was found. An adhesion at the base of the loop was broken up with the finger. Without attempting to particularly identify the bowel, the loop was brought out on the abdominal wall and closure of the wound was made as rapidly as possible. A normal saline solution was injected subcutaneously during the operation. The patient had a very stormy convalescence. Forty-eight hours after operation, 28 inches of gangrenous small intestine was removed without anæsthesia, and a fistulous opening from the small bowel remained. This loop was later identified as distal ileum. Four weeks following the enterostomy, the fistulous opening in the bowel was closed. The abdomen was reopened and a lateral anastomosis was made between the ileum and the ascending colon. The distal portion of the enterostomy loop having sloughted completely away, there was an opening at the ileocæcal junction. The gangrene

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of the small bowel had been due to a thrombosis of both arteries and veins to that portion of the small bowel involved. Three weeks following the lateral anastomosis, the

FIG. 2.—Ileostomy following intestinal obstruction.

patient again had symptoms of intestinal obstruction. The abdomen was reopened and numerous adhesions were found along the distal ileum which were occluding the

Lateral Anastomosis of ileum to caecum
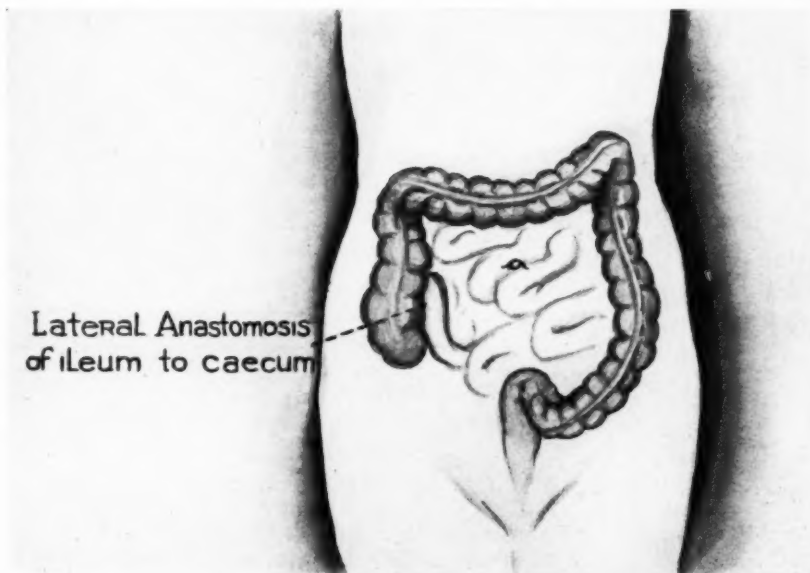
FIG. 3.—Lateral anastomosis following Ileostomy for intestinal obstruction.

lumen of the gut. Because of the large area of small bowel involved by adhesions it was not thought wise to resect it. The numerous adhesions were broken up with the

finger. The abdomen was closed in the usual manner. The patient was seen ten months following the last operation. He has gained about fifteen pounds in weight and is in fair condition.

In the region of the cæcum, fæcal fistulas are not uncommon following appendiceal abscess or perforations of the cæcum due to foreign bodies, and as a complication of appendectomy where tuberculosis of the cæcum is present. In fistula following appendiceal abscesses, closure is often spontaneous, and when the fistula persists, a suspicion should be entertained that we are overlooking some pathology about the ileocæcal region such as adhesions about the ileum, tuberculosis, or neoplastic diseases of the cæcum itself.

Fistulae in this region may cause extensive excoriation of the skin, due
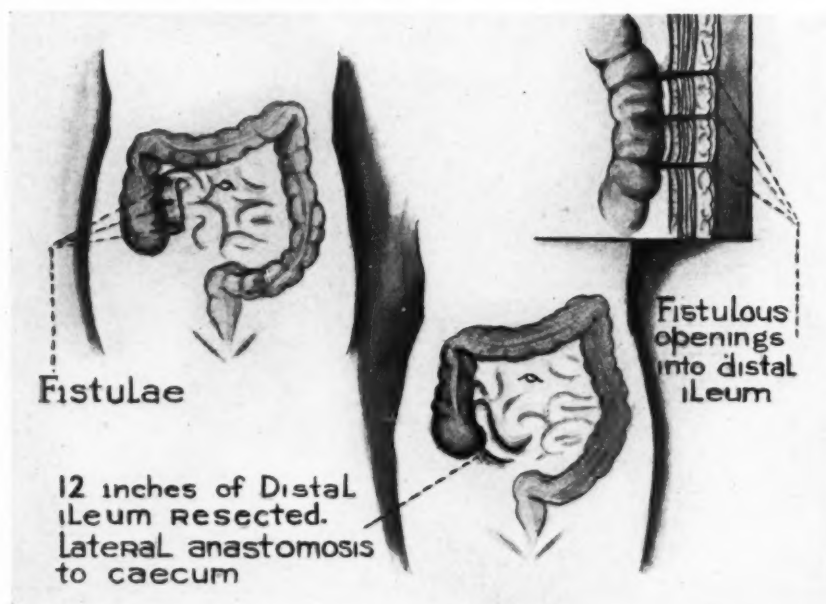
FIG. 4.—Lateral anastomosis for repair of persistent fæcal fistula.

to irritation of the fæcal current. But by protection of the skin, this can be greatly eliminated. There is usually a loss of weight present, and some dehydration, the latter, however, is not marked. These patients often give a history of having had attempts made to close the fistulous opening, which have ended in failure. The underlying pathology, such as tuberculosis of the lung, or emaciation, may give a clue to the true condition. Fluoroscopy can be employed, either by the direct injection of the sinus itself, or by giving a barium enema. The following cases illustrate this condition:

CASE IV.—Mr. O., aged thirty-six (Fig. 4), a patient in the Oak Forest Dispensary in 1925, had been operated at the Cook County Hospital two years previously for a suppurative appendicitis. His present complaint was escape of fæcal material from three fistulous openings in the right lower quadrant of the abdomen with marked loss of weight. Because of inadequate X-ray facilities and a belief that the cæcum alone was involved, attempts at closure were made by dissecting the sinus tract down to the

bowel wall, and closing the opening in the bowel with interrupted sutures. Two attempts were made, both being unsuccessful.

The patient reported to the Presbyterian Hospital and on injecting barium into the tract through a catheter it was readily seen that the cæcum as well as some portion of the small bowel, probably distal ileum, was involved. Under general anæsthesia, the abdomen was opened medial to the operative scar and 12 inches of the distal ileum, about 6 inches from the ileocæcal valve, were found adherent to the abdominal wall from which three fistulous tracts extended to the exterior. One of the tracts connected with an opening in the cæcum. The tracts were dissected free; the opening in the cæcum was closed; the ileum involved was resected and a lateral anastomosis was made between the cæcum and the ileum. The abdomen was closed in the usual manner without drainage.

The patient made an uneventful convalescence and gained 60 pounds in ninety days.
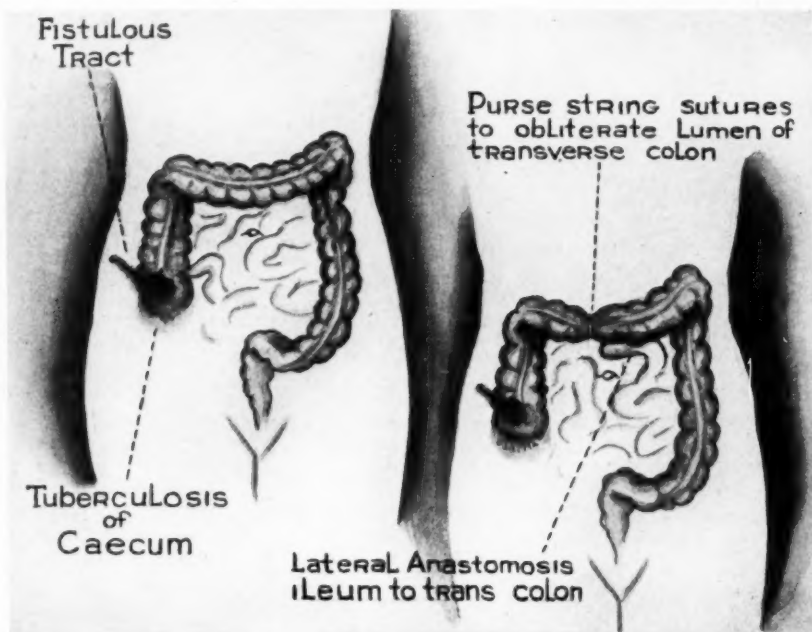
FIG. 5.—Lateral anastomosis with obliterating of caecum.

He left the Oak Forest Dispensary and returned to work, and when last seen was enjoying excellent health.

CASE V.—R. J., aged twenty-eight (Fig. 5), had been a patient at the Oak Forest Hospital for eight months with a fæcal fistula at the ileo-cæcal region. He had an appendectomy some time previously, at which time a diagnosis of ileocæcal tuberculosis was made. Following the operation of appendectomy, a fæcal fistula formed and most of the fæcal current passed through the fistulous opening. Because of the poor nutrition of the patient, it was thought that closure of the fistula should be attempted. Accordingly, a right rectus incision was made. The cæcum and ascending colon were found adherent to the surrounding structures. The ileum was resected, and an anastomosis to the transverse colon, at about its middle, was done. Because of the poor condition of the patient, the transverse colon was not resected. Three purse-string sutures were passed about the transverse colon, and the lumen of the colon, proximal to the anastomosis, was obliterated in this fashion. The abdomen was closed in the usual manner and a drain placed in the cul-de-sac.

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The patient had a stormy convalescence, and when last seen, about six months later, he had a mucous fistula at the ileocæcal region. There had been some improvement in health, and some gain in weight.

CASE VI.—E. W. (Fig. 6), a colored male, twenty-five years of age, was transferred from the Oak Forest Tubercular Sanitarium to the General Hospital with the diagnosis of fæcal fistula and pulmonary tuberculosis. He had been operated six months previously for what was thought to be appendicitis. Following his operation, he developed a fæcal fistula at the site of the wound in the lower right quadrant of the abdomen. There were also numerous small fistulous tracts from which pus exuded. It was thought that if the fistulous tract could be closed, the nutrition of the patient might be so improved that his general condition would be better. Accordingly operation was advised.

Under local novocaine anæsthesia and nitrous oxide, the abdomen was opened medial
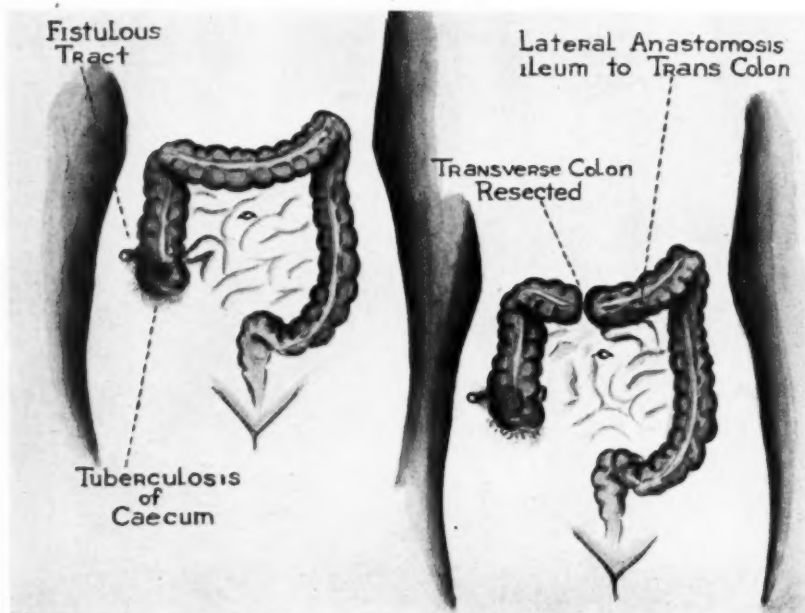
FIG. 6.—Lateral anastomosis with obliteration of caecum.

to the site of the old scar. The cæcum was found to be hypertrophic and adherent to the surrounding structures, so that colectomy was out of the question. Accordingly the transverse colon was resected at about its middle. The ileum was resected at the ileocæcal valve, and a lateral anastomosis made between the terminal ileum and transverse colon. The cæcum, ascending colon, and a portion of the transverse colon were left in situ. The abdomen was closed without drainage.

The patient had a rather a stormy convalescence, and improved in health for one year. The fistulous tract in the meantime drained a muco-purulent material. He succumbed to miliary tuberculosis.

Fistulae of the lower bowel are of chief concern because of the accompanying peritonitis, and nothing more, as a rule, beyond drainage of the wound is indicated in the immediate treatment. With the formation of fistulous tracts it may be necessary to drain an abscess pocket which has prevented healing, or by regulating the diet to produce firm stools, the fistulæ

may close spontaneously. Injection of the tract may be tried, if these measures fail. Operative intervention to close the fistulæ should be reserved until all conservative measures have been tried.

CASE VII.—Miss R. S., aged twenty-five (Figs. 7 and 8), entered the Presbyterian Hospital, May 6, 1929, with the following history: Two years previously, the patient was operated for an acute suppurative appendicitis, following which she developed a pelvic abscess.

The abscess was drained supra-pubicly, and following her discharge from the hospital a small fistulous opening was present at the lower end of the mid-line wound. This fistulous tract discharged fæces, and she said when mercurochrome was injected into the fistula, it would appear in the urine and fæces. Attempts were made to close the fistula by injecting mercurochrome, with the result that the bladder fistula closed, but the escape of fæces occurred nearly every day. Cystoscopic examination was done by Doctor Kretschmer, who reported that at about the juncture of the posterior wall with the base, there was a slight prominence of bladder, as though there was something outside of the bladder wall pushing it in. It was impossible to catherize this depression, and this is probably the site of the closed fistulous tract. Under the fluoroscope a tube was inserted into the sinus, and lipiodol was injected into the sinus. The lipiodol passed downward to the left of the sigmoid colon and there appeared to be a large area which extended backward to the sacrum. Barium was then injected through the rectum, the rectum filled well. As the barium passed into the sigmoid loop it was continuous with the large tube-like lipiodol injection; in other words, this patient has a sinus connected with the sigmoid portion of the colon. The sinus tract was injected every other day with a modified Beck's paste. The discharge became less in amount, though at times the paste would be found in the bowel movements. Forty days later there was very little paste found in the bowel movements, and there was very little discharge from the sinus. The sinus was then injected with 5 cubic centimetres of 5 per cent. formaldehyde in glycerin. The patient complained of bearing-down pains following this injection, but there was no further discomfort and this was done at weekly intervals during the remainder of the time she was in the hospital.

She left the hospital October 27, 1929. She remained in very good health for about one year, when she noticed that fæces were again being discharged from the fistulous opening. She again returned to the hospital May 25, 1930, and on May 26, 1930, the following operation was performed:

The mid-line scar was dissected free and the abdomen was opened. Loops of small gut and omentum were freed from the abdominal wall. The fistulous tract was traced down to the rectum; the tract in the rectum was dissected free and was closed with interrupted linen sutures. The descending colon was pulled out of the abdomen and was anchored in place for a temporary colostomy. The next day, because of the distention of the abdomen, the bowel was opened with a cautery. The convalescence was stormy. Ten days following the operation there was a partial evisceration, and the wound was closed with tension sutures without the use of an anæsthetic. The condition of the patient remained very good. The operative wound healed and one month later the spur of the colostomy was removed by the Pauchet method. The bowel was then covered with skin and muscle. The patient was discharged from the hospital October 2, 1930, with the fistulous tract closed. Her health improved. November 3, 1931, she returned to the hospital because of symptoms of low-grade obstruction. She remained in the hospital one day.

The fistulous tract is entirely closed and while her health is greatly improved, there is always danger of recurrence of obstruction.

CASE VIII.—Mrs. G. K., aged twenty-eight (Fig. 9), entered the Presbyterian

Hospital, January 16, 1929, with the following history: The patient was operated seven years ago for removal of a right ovarian cyst. Following the operation, the wound
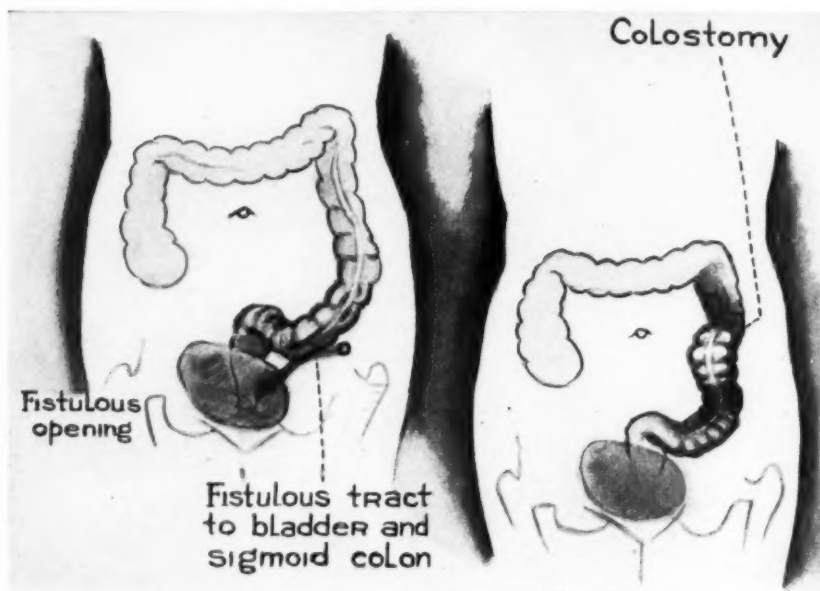
FIG. 7.—Temporary colostomy after repair of fæcal fistula.
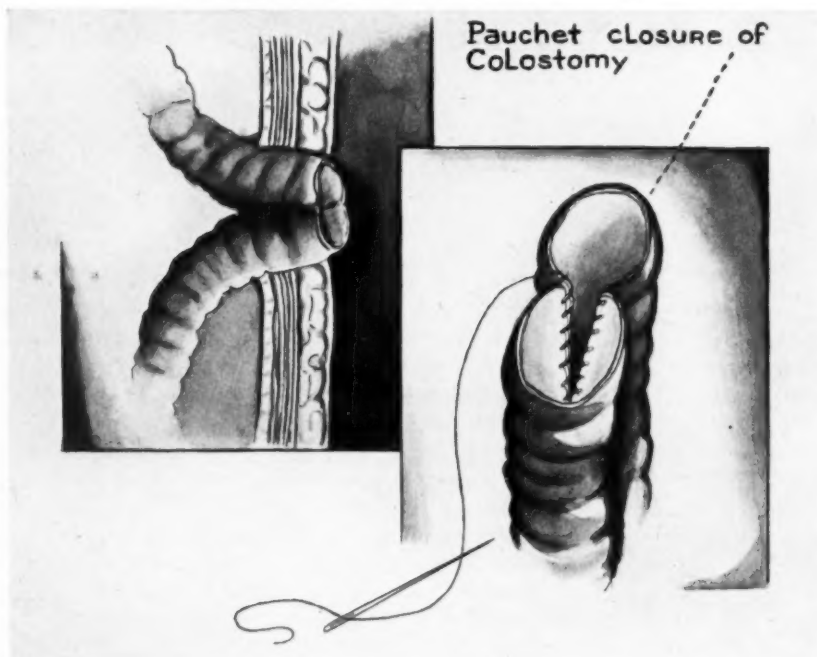
FIG. 8.—Pauchet closure of colostomy.

drained for several weeks and a fistulous tract was established which has been present ever since, and from which fæces appeared nearly every day.

There is a mid-line scar which extends from the umbilicus to the symphysis. At the lower end of the scar there is a small fistulous opening. At operation the old scar was dissected out and the peritoneal cavity opened. Omentum, small bowel, sigmoid colon and broad ligament, and a right-sided ovarian cyst, the size of a small coconut, were found in the dense adherent mass. The fistulous tract was dissected down to the sigmoid and to a seminecrotic area on the top of the bladder. During dissection, the bladder was ruptured with escape of urine. The sigmoid was dissected loose from its adhesion to the round ligament and to the ovarian cyst, and the fistulous opening in the sigmoid was closed with linen and reinforced by a fat epiploicae. A loop of ileum was pulled into the wound and a rubber tube inserted, and an ileostomy performed. The tear in the bladder was sutured, the ovarian cyst was marsupialized because it was impossible to remove it, and the abdomen closed without drainage.

The patient was in the hospital forty-nine days, and upon leaving the hospital there
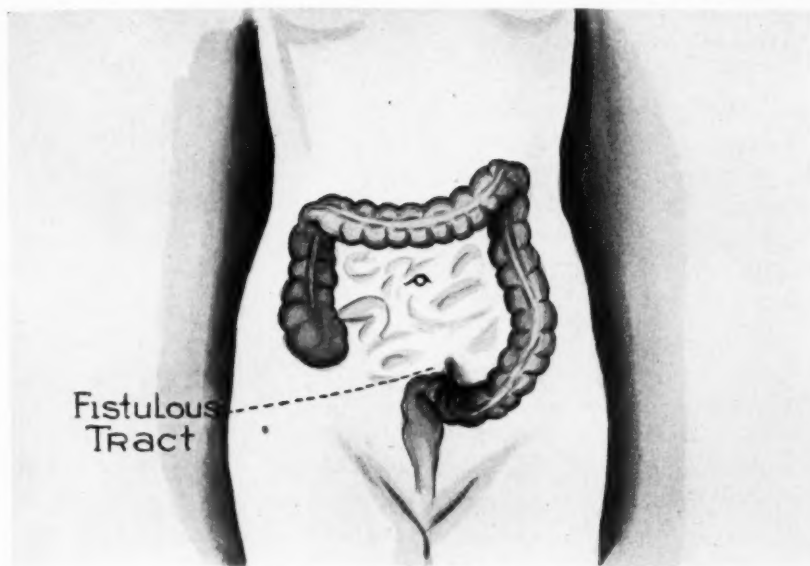
FIG. 9.—Fistulous tract for sigmoid colon.

was no evidence of fæcal discharge from the wound. June 28, 1931, she returned to the hospital because of three small draining fistulae at the lower end of the abdominal scar. The patient had improved in weight but because of the troublesome discharge from these fistulæ, operation was advised. The old scar was dissected; two large ovarian cysts were isolated and drained; and the fistulous opening was again dissected down to the sigmoid. The bladder was again opened during the dissection, and was closed by catgut sutures. There was also a small defect in the ileum where the previous ileostomy had been done. This defect was dissected, and closure of the ileum was made. A Pezzer catheter was passed through the urethra into the bladder.

The patient remained in the hospital twenty-six days. When she was seen two months later, the wound had healed. There was a small opening at the lower end of the scar from which a mucous secretion was secreted. The patient was gaining weight, and felt better than she had felt for some years.

The treatment of intestinal fistula concerns itself chiefly with the location and chronicity of the lesion. In fistulae arising from the duodenum and lower jejunum, the blood chlorides and body fluids, as well as body nutrition,

are of prime importance, and measures should be directed to furnishing chlorides in the form of normal saline, and nutrition in the form of glucose, either by hypodermoclysis, rectal infusion, or by both methods. The fistula itself should not be treated by direct suture. In fact, so many failures have been reported 'that a conservative attitude should be employed. The skin and operative wound should be protected as well as possible, and this may be done with a liquid adhesive plaster, kaolin, or other ointments, and the sinus tract itself may be plugged with a modified Beck's paste. The pancreatic secretions may be inactivated by use of an acid media and continual suction of the wound may be advantageous. The treatment in this type of fistula is one of prevention, as many of them follow cholecystostomy or trans-duodenal removal of biliary stone. Care in breaking up adhesions about the gall-bladder with immediate repair of injury to the duodenum, as well as careful suturing of operative incision in the duodenum, will greatly lessen the incidence of this very serious condition.

Fistulous tracts in the ileocæcal region are more favorable for operative treatment than in any other region. The intestinal content is not highly infective; the peritoneal cavity shows a resistance to infection, and healing of the repaired viscera usually takes place.

In the lower abdominal tract, as many of these fistulae arise as a result of removal of adherent organs, gentleness during operative procedures and repair to the traumatized gut will greatly reduce this condition.

During the acute stage of fistula formation, the treatment is, of course, directed toward the local or general peritonitis, whichever is present. Many of these fistulae close spontaneously, and here too, the tract may be injected with a modified Beck's paste, and obliteration of the sinus may result. In the chronic type, however, operative procedures are a very formidable undertaking because of the dense adhesions present and the involvement of other organs by these adhesions. In the lower sigmoid, a colostomy is often advantageous after the repair has been made. The colostomy may be closed several weeks later, and this procedure promises the best results in this type of fistula. The incidence of peritonitis following the operative repair is not so great as one would expect, and is probably the result of protective processes which have arisen from inoculation to the peritoneal cavity by the infected fæcal current of the sinus.

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INTESTINAL FISTULÆ

A Method for Preventing Digestion of the Skin

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The management of intestinal fistulæ is difficult, due to (1) inanition and dehydration of the patient, and (2) the vicious action of the intestinal contents upon the skin and abdominal wall around the tract. It has long been recognized that the higher in the intestinal tract the opening occurs, the more irritating the discharge. The destructive action of high intestinal fistulæ is due largely to the presence in the discharge of unaltered pancreatic juice which is a rapid digestant of protein. Spontaneous closure of such a fistula might often be anticipated, or a successful surgical procedure considered if the ulcerated surface around the fistulous mouth could be protected from the continual assault by the intestinal contents. A method of accomplishing this protection is described in this paper. It has been used twelve times in this clinic with very satisfactory results.

Commentors on the subject have mentioned many drugs and methods which were thought to have been of value in protecting the skin about a fistula and in relieving the patient of the intense burning pain usually accompanying the lesion. Among the many dressings recommended are: Olive oil, vaseline, zinc oxide, sodium fluorid, paraffin, benzoin, iodoform, kaolin, liquid petrolatum, acetic acid, glue, lanolin, *et ad infinitum.*

Ochsner[1] reported a case of cæcal fistula with marked digestion of the skin, much improved in three days by a diet of egg albumin. Closure was effected by operative means. Erdman[2] treated a duodenal fistula by a continuous suction apparatus suspended from a semicircular frame designed by Pool. A jejunostomy had also been made, and both openings closed spontaneously with this treatment only. Cameron[3] in a case with duodenal fistula following partial gastrectomy, used continuous suction by means of a catheter placed into the opening. Closure of the fistula occurred eleven days after the suction treatment was instituted, without operative assistance. Rees[4] treated a duodenal fistula, also following gastric resection, by dressings of whole milk (commercial). It is said to neutralize all of the ferments found in the intestinal discharge since it contains protein, carbohydrate and fat. Potter[5, 6] reported a number of duodenal and high jejunal fistulæ treated by dressings of tenth normal hydrochloric acid and beef broth mixed with olive oil. The physiology of this procedure seems sound, since the alkaline discharge is neutralized by the acid, and the beef broth is a protein upon which pancreatic juice may direct its digestive action. Potter's[6] later report indicates that acetic acid is not a satisfactory substitute for hydrochloric acid in this form of treatment. Warshaw and Hoffman[7] modified Potter's method by introducing hydrochloric acid directly into the intestine at the opening of the fistula by catheter and by bathing the adjacent skin with Witte's peptone solution (10 per cent.). They suggested the substitution of peptone for beef broth as the former is more easily prepared and readily procurable. Bohrer and

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Milici,[6] in a recent report on duodeno-cutaneous fistulæ describe the use of a one-half inch fenestrated rubber tube in the fistulous tract to act as a reservoir for the discharge. A smaller tube, attached to a water-pump suction, is placed inside the larger tube and removes the discharge.

We have abandoned, some time ago, any attempt to protect the skin around an intestinal fistula by medicated dressings or mechanical covering, since these frequently shut off from contact with the air, a surface which would be better air dried. We now prevent, or minimize digestion and ulceration of the skin by keeping the irritating discharge from coming in contact with the skin about the stoma. The area is cleaned off with alcohol and dried, and no medication or dressing is applied. A continuous suction apparatus (centrally controlled) is used during the hours when the patient is awake. A glass-tipped rubber tube, in the hands of the patient himself,
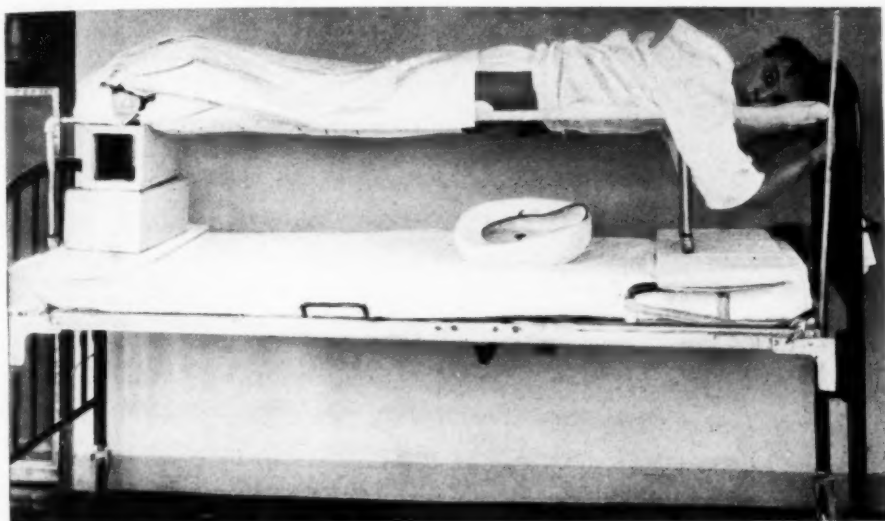
FIG. 1.—Patient with fecal fistula lying on anterior Bradford frame showing opening in the frame. (Pillows under elbows have been removed for clearness of picture.)

has proved to be the most satisfactory method of applying this suction, since plugging of the tube, or cessation of the suction is immediately discovered, and may be corrected. This plan also provides the patient with an occupation which, though not exactly pleasant, stimulates his interest in his progress, and makes him a much better attendant than average nursing care affords.

The difficulty with this form of treatment has been that during the hours of sleep the discharge collects on the skin, and in a few hours digestion and erosion have occurred, vitiating the result of a day's careful attention. This problem we have found to be excellently cared for by placing the patient on an anterior Bradford frame (Fig. 1) with a slit opening in the region of the fistula.

A bedpan, placed beneath the opening on the bed, serves as a receptacle for the discharge. Within a very short time patients accustom themselves to such a frame, and
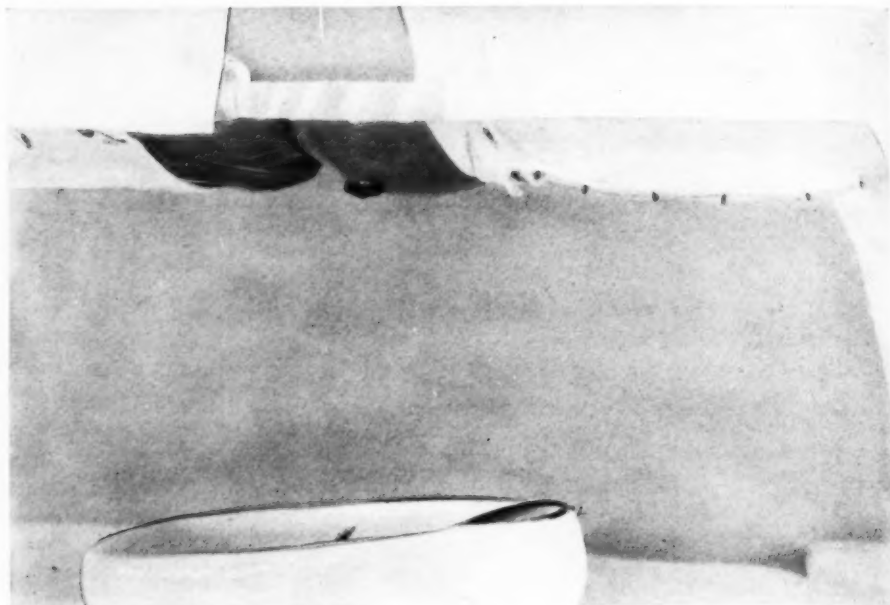
FIG. 2.—Close up of same patient as in Fig. 1 showing prolapse of bowel. Note cleanliness of the skin despite the continuous discharge even while the picture was being made.

sleep comfortably through the night, as well as during a rest period in the day, with ideal care of the fistula requiring no conscious effort on the part of patient or attendants. The dependent position of the fistula, in most cases, tends to produce some degree of prolapse of the bowel mucosa (Fig. 2) so that the opening in the bowel is some distance
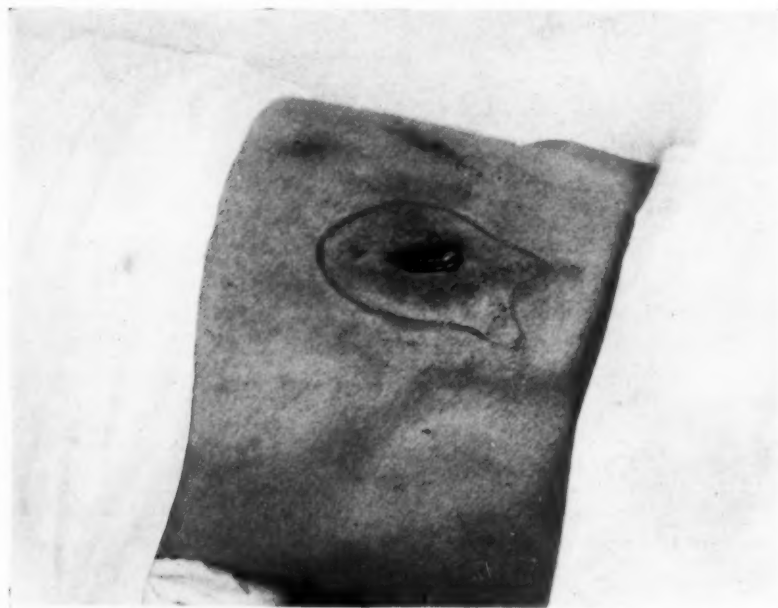
FIG. 3.—Same patient as Fig. 1. Pencil marking on skin outlines area which had been ulcerated from discharge. Completely healed at the time of the photograph.

from the skin surface. The fistula then assumes somewhat the character of a well-made colostomy, with the actual opening in the bowel far enough below the skin surface to prevent soiling of the skin as long as the patient lies in a prone position.

CASE REPORT.—N. T., No. 253063, male, age thirty-two, entered the University Hospital November 10, 1930, complaining of a fecal fistula in the lower abdomen. A perforated appendix had been removed April 3, 1930. The abdomen was drained and within two days gas and fæces escaped from the wound. Three attempts were made to close the fistula, six weeks, eight weeks and four months, after the appendectomy. The patient's general condition had become progressively worse with great weight loss, and pain about the fistula requiring large amounts of opiates for relief.

The patient was an emaciated, dehydrated male, acutely ill. In the right lower quadrant of the abdomen was a large fecal fistula surrounded by an area of ulcerated skin 12 centimetres in diameter. Several healed scars were seen in this region. Three openings into bowel were demonstrated, one of which discharged bile-stained fluid soon after the ingestion of water by mouth. The patient complained of extreme pain about the fistula, was ungovernable, and for the first two days of hospitalization, required considerable narcotic. He was at once placed on constant suction combined with the anterior Bradford frame. Within four days, healing of the skin had progressed so that the patient was comfortable and required no sedative. Ten days after admission November 20, 1930 the abdomen was sufficiently healed to permit surgical closure of the fistulæ. This necessitated resection of 15 centimetres of high ileum in which two openings were found, the third opening being in the lateral wall of the cæcum. Convalescence was not unusual and patient was discharged on December 24, 1930. Three months later he was entirely well and had gained fifty pounds in weight.

SUMMARY

1. Drugs and dressings of various kinds applied to the skin surrounding a high intestinal fistula are not wholly satisfactory.

2. Greasy dressings seal the skin from the air and are distinctly of no value

3. A continuous suction apparatus, operated by the patient himself, forms a satisfactory means of preventing digestion of the skin.

4. The prone position on an anterior Bradford frame provides the best care while the patient is asleep.

5. The time required for spontaneous closure or in preparation of the field for operation, may be appreciably shortened by the continuous suction and Bradford frame form of treatment.

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THE PREVENTION OF FÆCAL FISTULA AFTER APPENDECTOMY

SIMPLE LIGATION VS. PRECARIOUS PURSE-STRING

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"Fewer errors occur in simple manipulative processes than in those of complex nature. The more we omit the multiplicity of detail and bring surgical technic down to an irreducible minimum of simplicity, the greater will be our reward in the ease and number of recoveries. * * * The easier the method, consistent with security, the sounder its qualifications."—ROYSTER.

"The workman who does his work in as simple a way as possible usually does the best job. * * * Cumbersome, complicated ways of doing things are not allowable in the development of the art of performing surgical operations."—E. STARR JUDD.

"The surgeon must seek always and earnestly for simpler methods and a better way. In the craft of surgery the master word is simplicity."—MOYNIHAN.

RECENTLY attention has been called by several medical writers to the general increase in the mortality of surgical operations, particularly appendectomy. One explanation which has been offered of this general increase is that quite generally throughout the country untrained physicians, though *legally* qualified, are undertaking to do major surgery. Prominent surgeons have discussed the matter, and there have been some suggestions of action by the American Medical Association, but nothing has developed and the profession in general seems quite apathetic. Legislation requiring a second examination of all doctors desiring to pose as specialists, so that those qualified for the specialty would be registered, would certainly aid materially in reducing the present death-rate following surgical procedures. However, the mortality of appendectomy cannot be entirely attributed to the inexpertness and poor judgment of amateurs, since a good many surgeons believe that it is in no small part due to the inherent dangers of a certain rather common method of operating.

The method referred to is the one usually known as the "purse-string," in which (1) the meso-appendix is detached from the appendix; (2) the base of the appendix (previously crushed in the technic of some operators) ligated with catgut or silk; (3) the appendix cut away about one-fourth of an inch beyond the ligature, by knife, scissors, or electric cautery; (4) the mucous lining of the stump of the appendix cauterized by carbolic acid or the tip of an electric cautery point, or the mucous membrane removed by a little scoop; (5) a purse-string suture, usually of six or eight stitches, inserted around the stump; (6) the stump depressed and (7) the suture tightly tied.

In looking through the different text-books, all authors are found to mention the purse-string method, and some of them seem to distinctly favor it. Thus, in Lewis' "Practice of Surgery" the chapter on "Appendi-

citis," as re-written for insertion in July, 1931, describes no other method but assures the reader that this method is "simple and safe."

Among the dangers of the purse-string technic is that its use necessarily cuts off a part of the blood supply to the area encircled. I once entered an operating room just as the operating surgeon had brought into view the cæcum from which he had removed an appendix by the purse-string method some three or four days before; the child had done well until a few hours before, when suddenly it went into collapse with great pain. *The encircled bit of cæcal wall had simply dropped out*, and the fæcal contents were pouring into the peritoneal cavity through an opening through which one could easily thrust a finger. The child was dying. Within a very few weeks I was told of two other cases of similar slough.

Harris,[1] of San Francisco, reports a case in which, at the time of the placing of the purse-string, the operator noticed that he had pricked a small vessel which caused a hæmatoma in the wall of the cæcum, but this seemed to be controlled before he closed the abdomen. The patient seemed to do well for three days, but then complained of pain with evidence of internal hæmorrhage; on opening the abdomen a large amount of free blood was found and the entire wall of the cæcum necrotic. The patient promptly expired.

Roeder,[2] of Omaha, found that of one hundred appendectomies made with the purse-string suture, 88 per cent. of the needles and remaining pieces of suture gave positive growths on culture media, proving clearly that the needle had penetrated one or more times the mucous membrane of the cæcum. He also called attention to the added danger when the base of the appendix is crushed, since his laboratory investigation had shown that the crushing clamp was found to be frequently contaminated by the infectious material forced to the surface by the crushing process. Furthermore, the ligature which is placed in this crushed groove is not only in an infected field but in devitalized tissue very likely to give way from internal pressure, conditions very different from those described and illustrated by Seelig.

Horsley[3] calls attention to the perfect incubation chamber furnished by the purse-string enclosing the depressed stump, as presenting "first, the diminution of the blood supply to the tissues * * *; second, the presence of necrotic material; and third, the formation of a closed sac";—all perfect conditions for abscess formation!

All authorities agree that the wall of the cæcum is the thinnest part of the entire alimentary canal and that the contents of the cæcum are the most highly infected. No author being found who gave the exact thickness, studies instituted at my request by physicians making frequent autopsies showed its thickness to be only *one-sixteenth of an inch*. The wall consists of four layers, the peritoneal, muscular, submucous and mucous. It would seem to be clearly an absolute impossibility for any man to put in the usual purse-string suture without running the gravest possible risk of penetrating infected tissue, so that his suture material would almost certainly become infected, as shown by the experiments of Roeder! Indeed, Roeder informs me that he has found the wall of the cæcum one-half inch from the base of the appendix, where the purse-string is usually placed, only *one-thirty-second* of an inch thick!

A number of surgeons sever the appendix with the electric cautery; this

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would certainly sterilize the surface actually touched by the cautery, but, as shown by Roeder, the tip of the cautery, if used to destroy the lining of the funnel of the appendiceal stump, does not always reach deeply enough to sterilize, and in this respect is greatly inferior to carbolic acid.

Hamilton Bailey,[16] of London, in his recent work on "Emergency Surgery" fully describes his appendectomy technic, which is that of the purse-string, but directs that the stump be "wiped with a gauze swab," and then proceeds, without further sterilization, to bury it in the incubation chamber.

Babcock[4] seems to trust entirely for sterilization of the stump to severing it with the actual cautery. As to the purse-string he adds: "Purse-string, occluding, or enfolding sutures in the cæcum, after removal of an infected appendix, are unnecessary and harmful, favoring large sloughs in the head of the cæcum."

The one-sixteenth, or less, of an inch space in which the surgeon must insert his purse-string has always reminded me, and I think very appropriately, of the theological plight of Charles Wesley, as shown by a verse in one of his well-known hymns:

> "Lo! on a narrow neck of land,
> 'Twixt two unbounded seas, I stand,
> Secure, insensible:
> A point of time, a moment's space,
> Removes me to that heavenly place,
> Or shuts me up in hell."

The surgeon who undertakes to insert a suture in tissue one-sixteenth of an inch thick may possibly feel "secure," if not "insensible," but if the patient knew the narrow straight between sterility and infection—between safety and peritonitis—he would certainly feel very far from either "secure" or "insensible." Would any patient select a technic which gives from 1.4 per cent. to 18 per cent. of fæcal fistulas about one-half of them necessitating a second operation, in preference to a method giving only one such fistula in many thousand operations?

Fæcal Fistula.—First place among the unfortunate "sequelæ" of appendectomy, is given to "fæcal fistula" by Royster[5] in his work on "Appendectomy." Howard A. Kelly[6] quotes five surgeons as having respectively 3.5 per cent., 5 per cent., 4 per cent., 18 per cent. and 6.6 per cent. of fæcal fistulas. Deaves[8] reported 4.8 per cent. Pfeifer and O'Connell[7] report 1.4 per cent., based on over 3,000 cases.

What particularly attracted my attention to the dangers of the purse-string was this large percentage of fæcal fistulas reported by surgeons who used that method. I could not recall a single one of my own cases in which I had met with any such complication, and this led me to go through my entire files, with the result that I found but one case in which anything like such a sequel appeared though I had operated on quite a number of such fistulas in which the primary operation had been made by a previous op-

erator. The absence of such a complication in my own work seemed to me could only be explained by the difference in technic.

Noting the reports of increased mortality of appendectomy and of this frequency of fæcal fistulas, I reviewed my own records and found that up to July 1, 1931, I had made 10,353 appendectomies. Of the earlier ones some were made by excision of the base with closure by a double row of sutures, or by the inversion method of Edebohls, but the great bulk were made by the method of Seelig,[14] *viz.*, ligation, amputation, carbolization, and dropping. I always had a feeling that the purse-string suture was a dangerous proposition, and therefore could never bring myself to employ it because of what I thought were its inherent dangers. With very few exceptions, as in cases which were operated upon at distant homes or in hospitals outside of Columbus, all of these patients, without regard to social or financial status, were carefully studied by me before operation and in the after-treatment were seen by me once or twice each day; of each case I have quite full typewritten histories. These cases, therefore, are in distinct contrast to many hospital cases which are seen by the operator only at the time of operation.

During all these years I have had a salaried first assistant, and in going over these statistics I supplemented the information thus obtained by a personal communication with each one of these assistants, not one of whom could recall a single case of post-operative fæcal fistula, except as stated. That one case occurred in a man sixty-four years of age, with a gangrenous appendix; parts locally otherwise in good shape, and no drainage was placed. He promptly developed a superficial infection in the fat of the abdominal wall, which discharged and after a few days extended inward, in two weeks resulting in a fæcal discharge. In due time this drainage ceased of itself, but there still persisted a purulent sinus which annoyed him so that six months later it was dissected out; the removal of the sinus, which had developed a distinct lining, ended his whole trouble and he is now, ten years later, still alive and well.

Taking for illustrative purposes the year in which the number of appendectomies was the largest, 141 were made primarily for appendicitis, and 392 incidentally in connection with other operations; eighteen were made for simple acute appendicitis; sixty-seven for chronic or subacute appendicitis; forty-five for gangrenous appendicitis (fourteen of them requiring drainage); eleven for abscessed cases. The deaths were:

(1) Boy, aged sixteen, operated upon on the sixth day at his home; condition bad and prognosis almost hopeless. General purulent peritonitis found as feared, and the appendix found free in the pus. Free drainage, but death in a few hours. (2) Woman, aged forty-three, in bad shape for four days. General purulent peritonitis; appendix thoroughly rotten. Free drainage; bad prognosis; death in a few hours. (3) Male, age forty. Usual symptoms of appendicitis for one week, but had been treated for "colitis." *Repeated chills.* Very large retrocæcal abscess; free drainage. Continued symptoms of pylephlebitis, and death from exhaustion in five weeks. (4) Chinaman, aged fifty-eight; sick five days. Had been freely purged. Extensive peritonitis; rotten

retrocæcal appendix with two concretions; free drainage; died the next day. (5) Male, aged thirty-six; had had several previous attacks but had refused operation; in bad shape. Gangrenous appendix back of the cæcum with much local infection. Died one week later of general peritonitis.

Physicians who may have been led to question the existence of such an entity as chronic appendicitis should read the discussions on that subject by the late John B. Deaver,[8] the distinguished Philadelphia surgeon, and the more recent article by Roy D. McClure,[9] Chief Surgeon to the Henry Ford Hospital of Detroit.

That the use of the purse-string is not followed by a prohibitive mortality can only be attributed to the powers of the peritoneum to take care of any reasonable amount of infection; but there is necessarily a limit to those powers, and to surgeons who have used the simpler technic the dangers of the more complicated method seem so great as to render its employment entirely beyond the pale of safety.

All surgeons will admit that the purse-string method presents a very pretty appearance, and from the outside looks very surgical; but when one considers what may be going on below the purse-string he might readily think of the "whited sepulchers" of St. Matthew, "beautiful outward, but within, full of uncleanness."

One cannot but consider, in these cases of fæcal fistula, that the occurrence of the fistula probably saved the patient's life, since otherwise death would have resulted from the extension of the infection in other directions; and there would seem to be no question as to infection, coming from some of the needle punctures of the cæcal wall, being responsible for many deaths which have been credited to "peritonitis." Moynihan's[10] "N" suture is a trifle safer than the usual purse-string, since it requires but four instead of the usual six or eight stitches, but as he crushes the appendix with a Doyen clamp before ligating he increases the danger.

Bailey,[16] of London, in writing on fæcal fistulas quotes approvingly an aphorism of a former colleague of his: "If a patient with peritonitis develops a fæcal fistula, he does not die"; his explanation being, of course, that a fæcal fistula acts as an enterostomy. In a considerable number of cases I have been called in consultation when the patient's condition after operation was hopeless; general peritonitis was present in all of them, and inquiry showed that the purse-string had been used in each of these cases. A number of years ago Dr. Robert T. Morris, of New York, published an article detailing his technic, which was the same as Seelig's. Recently in response to a letter of inquiry as to fæcal fistulas, he replied that he *had had none since he adopted that method*.

Perhaps the lack of fæcal fistulas in my records may be due in part to the fact that if the base of the appendix is involved with some infiltration of the adjacent wall of the cæcum, the involved portion of cæcum is removed by an elliptical excision and the opening closed with a double row of catgut stitches. Repeatedly interns or nurses have anxiously reported

the presence of a fæcal fistula, but examination has shown a simple colon bacillus infection in the superficial fat which promptly cleared up; the intern having trusted to the odor in making his diagnosis. It is reasonable to suspect that surgeons who have reported numerous fæcal fistulas have likely trusted to such statements of the attending nurse or intern without making a personal examination.

As it might very properly be said that statistics based in part on the routine removal of the appendix when operations were made for other conditions, would hardly be a fair criterion as to the appearance of fæcal fistula, it may be well to state that my records show that 3,215 operations were made for appendicitis; so that, according to the best published statistics available, there should have occurred at least thirty-five or forty fæcal fistulas.

The chief objections to the purse-string treatment are: (1) It requires much more time; (2) it necessitates more mobilization of the cæcum; (3) there is very great danger (88 per cent. according to Roeder) of the needle penetrating the bowel with resulting peritonitis; (4) distinct danger of a hæmatoma from pricking a vessel; (5) danger of necrosis of the encircled wall of the cæcum from diminished blood supply; (6) great increase of post-operative adhesions, with resulting post-operative ileus; (7) greatly increased danger of fæcal fistulas; (8) the constant menace from burying the necrotic stump in a perfect incubation chamber.

By correspondence and by reference to surgical literature I find that the purse-string method is condemned by many surgeons of large experience, most of whom are professors of surgery in medical colleges, and all are men of national and international reputation, so that their opinions are certainly entitled to grave consideration.

The simple drop method which was in vogue at Mt. Sinai Hospital when Seelig wrote his article condemning the purse-string, I am assured by one of the staff, is still in use by its twenty surgeons, and Berg, of that hospital, writes me that "it has been the method of choice there for the last forty years. I have used it in thousands of cases and have never known a fæcal fistula to develop after its use. The procedure is surely the simplest procedure that can be employed. The method is speedy and safe."

The Safer Incision.—When McBurney brought out his incision for appendectomy it seemed so satisfactory anatomically that I at once adopted it and used it for a considerable time, and even occasionally resort to it now; but I found in so many cases that the space afforded was so small, and the different methods suggested to enlarge this space so unsatisfactory, that I abandoned it as a routine and adopted instead the method advocated by Deaver and others, by which a straight longitudinal incision is made through the right rectus muscle, the point of making the incision being determined by the anticipated underlying conditions. This incision can be enlarged in either direction, and the surgeon is at once master of the entire situation, while the closing of the incision is a straight piece of work. Some writers have objected to it as requiring numerous ligatures, but no ligatures are

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necessary except when the deep epigastric has to be cut, when a single ligature is sufficient; other bleeding points are simply caught by a hæmostat for a few moments and bleeding always stops. I have never had any trouble with paralysis of the muscle from interference with its nerve supply. Surgeons who still favor the McBurney incision should read the article by Southam,[11] who condemns that incision because of the marked frequency with which an inguinal hernia develops after its use.

I am very certain that in scores of cases I have been able to coax a thoroughly gangrenous and tense appendix out through a right rectus incision which would unquestionably have burst had I undertaken to bring it out through a McBurney incision. Such successful removal makes all the difference between complete closure and drainage with its dangers.

Routine Appendectomy.—For many years I have advised and practiced the routine removal of the appendix in all cases in which the abdomen was opened, except when it might be found apparently normal in adults, or the condition of the patient such as to preclude any further operative procedure, no matter how simple. In 1903, I published a short paper[12] advising such removal, in which I reported 636 such cases, together with the conditions found at removal. In looking through my notes of the thousands of cases operated upon since then, I find practically the same relative proportion of the conditions thus found, except that in two or three cases I noted that the appendix was full of pus. *In not a single case was there the slightest evidence of complication following removal of the appendix, nor that its removal had been responsible in any way for any fatal issue.* The following conditions were present in the 636 cases: Thickened, 126; adherent to intestines, 90; to gall-bladder, 4; to omentum, 3; to ovary, 30; to fallopian tube, 36; partly obliterated, 65; club-shaped, 63; constricted, 22; thickened and swollen, 116; containing fæcal concretions, 13 (3 concretions in one case, 5 in another, and a seed in a third); cystic, 2; twisted upon itself, 23; atrophied throughout, 15; apparently normal, 27.

While surgeons in general seem fully to appreciate the wisdom of routine examinations of the appendix, there are still a few who advise against it and themselves ignore it, or if they incidentally examine are very loath to remove it. If such surgeons use a complicated method of removal their attitude is probably wise, but if they employ a simple method it is doubtless wrong.

Many years ago I operated on a man for a pistol wound of the stomach, both walls being perforated. I carefully closed both openings, but because of his bad condition did not examine the appendix. In a few days unfavorable symptoms developed, which I attributed to a leaking stitch; but the autopsy showed the field of operation in perfect shape and death to have been due to peritonitis from a gangrenous appendix. The patient was insane, so that his death, while no calamity, afforded a valuable lesson.

Soon after this a babe, seventy minutes old, was brought to me with a hernia into the umbilical cord. The intestines could be readily seen through the amnion, and at one point was a discharging sinus which I assumed was probably a Meckel's diverticulum, and such was found to be the case at operation. The diverticulum was removed

after the usual appendectomy technic, the abdominal opening closed in the usual way and the babe at once taken home. It continued to cry, except when asleep, from the time it was born until its death on the third day after operation. Autopsy showed a perfect peritoneum; the stump of the diverticulum had disappeared and the surface at that point was completely peritonealized; not an adhesion was present. Conditions were not favorable for a thorough autopsy to find the cause of death. It was, however, a perfect demonstration of nature's method of caring for such stumps.

Operative Technic.—The right rectus incision is rapidly made. If the intestines crowd into the incision they can easily be pressed back and to the left by inserting *moist* gauze sponges, making a coffer-dam if pus is suspected. Usually the appendix is readily exposed, but if it is not it can be quickly found by the following manœuvre: The assistant, standing on the left of the table, holds the cæcum, which has been brought out, with his right thumb and forefinger, and the lower end of the ileum with his left thumb and finger: just below the junction of the two the appendix, no matter if subperitoneal or how thoroughly covered by adhesions, will at once be found, and can be reached by separating overlying tissues with the handle of the scalpel. This use of the scalpel almost invariably exposes the appendix at its very origin, so that its subsequent removal is easy. This manœuvre is especially valuable in cases in which from extensive adhesions the longitudinal bands cannot be readily identified. (The relationship of the appendix to the cæcum and ileum may be compared to that of the genitals of a baby to its legs when the nurse holds the latter abducted and drawn up.)

The meso-appendix is ligated by transfixing it with a hæmostat and withdrawing a chromic catgut ligature. (Usually a single ligation is all that is necessary.) The meso-appendix should be ligated and detached as close to the base of the appendix as possible, so as to leave a minimum of stump with resulting minimum of possible adhesions. The appendix, with the remains of the meso-appendix attached, is brought up and ligated *tightly* with chromicized catgut No. 2 at its very base, so as to get below Gerlach's valve. Holding the ends of the ligature between the thumb and forefinger, the finger close to the knot, with the tissues below properly protected, a hæmostat is placed on the appendix a little above the ligature and the appendix cut away with knife or scissors, leaving a "button" of three- or four-sixteenths of an inch. With a probe dipped in pure phenol the edges of the appendix stump, and its funnel-shaped cavity lined with mucous membrane, are thoroughly touched, *being careful that the phenol reaches the very bottom of the funnel.* Any surplus phenol is wiped off, but the application of alcohol, as recommended by some who evidently are ignorant of the investigations made at the Johns Hopkins,[13] is entirely superfluous. The ligature is then cut short, and the stump of the appendix dropped. One-eighth to one-quarter of an inch has been left as a "button" to support the ligature.

The stump, thus dropped, and also that of the meso-appendix, almost invariably disappear from view, but if either projects so as to be a possible

point for adhesions it can easily be covered by a stitch or two so placed as by no possibility to penetrate the bowel.

The gauze sponges are then withdrawn, the omentum pulled down and spread out smoothly, and the incision closed by a continuous chromic catgut suture embracing the transversalis fascia and peritoneum, carefully turning the edges outward so that there will be no raw surface next to the underlying parts; with the same suture a running stitch is carried back approximating lightly the edges of the split rectus muscle, and then, still with the same suture, the aponeurosis of the external oblique is carefully approximated; several silkworm gut stay sutures are then placed, embracing all the tissues down to and including most or all of the thickness of the rectus muscle. These stitches being tied, all dead spaces are obliterated into which otherwise blood might ooze with a resulting hæmatoma. The edges of the skin are finally approximated by a running chromic catgut stitch and the usual protective dressing applied. ("Clips" are used by some operators, but they interfere with the dressings and increase discomfort.)

Drainage—Before closing the incision, if drainage is necessary, it should be made as a rule by a stab incision well over to the right, its best location being determined by a couple of fingers on the inside. The skin is incised for about one inch and a pair of scissors thrust through and opened. A hæmostat passed alongside the scissors withdraws the ends of any ligatures which have been used and which have been purposely left long, and then withdraws the drain; the distal end of this drain being placed in the infected pocket from which the appendix has been withdrawn, but not in such contact with the stump of the appendix as to increase the danger of necrosis; if the infection extends into the pelvis, the drain should be carried down to the bottom of the pelvis, but great care should be taken to so place it that, if possible, as is almost invariably the case, it is not in contact with the small intestines, but is protected by the ascending colon, the cæcum, or perhaps the sigmoid, or by the omentum pulled down and if necessary held in place by a catgut stitch. In this way post-operative adhesions will be avoided and post-operative ileus. Sufficient drainage can almost always be secured by a single cigaret drain, passed to the bottom of the pelvis if necessary; but in rare cases a soft rubber tube wrapped in gauze and with a wisp of gauze on the inside is preferable. Great care should be taken that there is no pressure upon the intestine from such a drain, since pressure interferes with the blood supply and may precipitate necrosis. (In neglected cases with extensive involvement of everything, wide drainage may be the only salvation of the patient, who must then run the risk of post-operative hernia, fæcal fistula and intestinal obstruction.) With such a drain in place, to be removed usually in two or three days or at the end of a week as the surgeon deems wise, the main incision can be closed completely and the danger of hernia thus minimized. If the sides of the main incision have been contaminated by contact with the gangrenous appendix or by discharge from the inside, the application of dilute tincture of iodine to the incision, after closing the

peritoneum and transversalis fascia to protect the abdominal cavity, will diminish the risk of local post-operative infection.

Suprapubic drainage should be avoided if at all possible, since the small intestine will almost inevitably come in contact with the drain and form undesirable adhesions. Almost invariably the pelvis can be drained through a stab incision far over to the right as previously suggested.

An objection has been offered to the ligature method that the ligature may be "blown off" by accumulation of gas in the bowel. I have never had such an accident, and I note that Horsley,[3] in discussing the matter, ridicules the suggestion, stating that it is "much less likely to happen on the stump of the appendix than on a blood-vessel. The stump of the appendix is soft and succulent tissue and the ligature sinks in well. Intracæcal pressure never even approximates the blood-pressure, so that if any surgeon is capable of ligating a large blood-vessel he should surely be able successfully to tie the stump of the appendix." In support of this statement by Horsley is the personal communication by Doctor Seelig that on several occasions he had taken at autopsy a fresh colon, ligated the appendix as in an appendectomy and then applied pressure with a force pump, with the uniform result that the colon always burst at its thinnest point but "there never was any strain on the ligature around the appendix." It would seem self-evident, however, that a ligature tied into the *crushed*, and hence devitalized and infected, base of the appendix, as by the technic of some operators, might readily result in disaster, especially when buried in an incubation chamber by the purse-string suture.

As years have gone by I have in a good many cases had to re-open the abdomen for ovarian tumor, fibroids, gall-stones, *etc.*, in patients from whom I had previously removed the appendix. I have always made it a point to examine the field of my former operation, but in no instance have I found more than the slightest of adhesions, if any, and have never had a single case in which resulting adhesions had produced ileus or, indeed, any noticeable complication whatever. *This absence of adhesions has been in marked contrast to what was almost invariably found in cases in which at the previous operation the purse-string had been used.*

In 1904, Major G. Seelig,[14] of St. Louis, published an article condemning the purse-string operation and urging upon surgeons the advantages of the much simpler procedure. Other prominent surgeons have practiced and urged the procedure described by him, but investigations seem to show that for some reason, perhaps the *vis inertiæ* of egoism, the more complicated operation is still widely practiced notwithstanding its evident large morbidity and mortality.

Aside from legislative requirements and improved technic, as suggested herein, satisfactory appendicitis statistics cannot be hoped for until we secure earlier operations through earlier diagnosis, perhaps along the lines suggested by Bastianelli,[15] who, about ten years ago, put his "creed" into three aphorisms: "(*a*) When physicians are discussing whether the case is ap-

pendicitis or not: it *is*. (*b*) When they are inclined to admit the possibility of appendicitis without being perfectly sure of it: it not only is, but it is about to perforate. (*c*) When the diagnosis is sure, there is already perforation, with a more or less circumscribed peritonitis."

The advantages of the simple ligation treatment are: (1) A minimum of time; (2) a minimum of manipulation of the cæcum; (3) no penetration of bowel, with its 88 per cent. of infection (Roeder); (4) no possibility of a hæmatoma; (5) no possibility of devitalizing the wall of the cæcum; (7) an absolute minimum of fæcal fistula; (8) no incubation chamber for the encouragement of abscess.

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CONGENITAL UNILATERAL RENAL AGENESIA *

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CONGENITAL unilateral renal agenesia may be defined as the congenital absence of one kidney. For a case to fit this definition, the other kidney must be composed only of elements derived embryologically from one renal bud. Aristotle was the first to describe this anomaly, according to Fortune. Consiliorum, in 1609, wrote the first description which has been preserved. Writers in former days paid slight attention to the clinical significance of this condition, because they believed it to be rare, and because it was often found only accidentally at necropsy of an elderly person who had died of a disease unrelated to the genito-urinary system. Thus, earlier accounts were usually only anatomic descriptions in which little effort was made to include either valuable clinical data or a complete description of the pathologic processes found. With the advent of surgery, toward the end of the nineteenth century, not infrequently nephrectomy was done when the patient had only one kidney, with fatal results. This served to attract attention to this anomaly and to instigate considerable research. Within the last twenty years, with the perfecting of examination by cystoscope and other diagnostic urologic procedures, attention again has been focused on this condition, and comment has arisen as to the possibility that such an anomaly might make the subject more prone to various types of renal disease or might influence the prognosis in cases in which disease of the urinary tract is present.

I wish to record nine cases that were observed in the Section on Pathologic Anatomy of The Mayo Clinic, together with data reviewed from a study of cases recorded in the literature. I have been able to consult original reports of 572 true cases. Reports of 513 of these cases were found in the literature and cited by other authors before me. (Table I.) Reports of the remaining fifty-nine cases (Table II) have been found in the literature and cited by me only. Forty-nine references to probable cases are listed in a separate bibliography as possible additional examples; I have not included them because I could not obtain the original articles.

Malformations of the kidney may be divided into five groups: (1) Marked secondary atrophy or destruction of one kidney; (2) various forms of renal fusion in which both kidneys are present and help to form the kidney which, on gross examination appears to be single; the "solitary kidney" of Rokitansky belongs to this group; (3) hypoplasia of one kidney, in which the atrophic kidney is much smaller than the other kidney, but is still

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TABLE I

Reports of Cases Found in Literature by Other Reviewers Than the Author of This Paper

Author	True cases	Year	Journal
Ballowitz................	213	1895	Virchow's Arch. f. path. Anat. u. Physiol., vol. cxli, pp. 309–390.
Moore...................	10	1898	Jour. Anat. and Physiol., vol. xxxiii, pp. 400–412 (April).
Anders.................	55	1910	Am. Jour. Med. Sc., vol. cxxxix, pp. 313–327 (March).
Dorland................	6	1911	Surg., Gynec., and Obst., vol. xiii, pp. 303–319 (September).
Braasch................	6	1912	ANNALS OF SURGERY, vol. lvi, pp. 726–739 (November).
Kelly and Burnam........	3	1914	New York, D. Appleton and Co., 582 pp.
Motzfeldt...............	15	1914	Beitr. z. path. Anat. u. z. allg. Path., vol. lix, pp. 539–563.
Gruber and Bing..........	13	1921	Ztschr. f. urol. Chir., vol. vii, pp. 259–299.
Eismayer................	75	1923	Ztschr. f. urol. Chir., vol. xi, pp. 191–220.
Eisendrath..............	30	1924	ANNALS OF SURGERY, vol. lxxix, pp. 206–228 (February).
Goldstein...............	18	1925	Southern Med. Jour., vol. xviii, pp. 750–757 (October).
Fortune................	3	1927	Ann. Int. Med., vol. i, pp. 377–399 (December).
MacKenzie and Hawthorne	1	1928	Surg., Gynec., and Obst., vol. xlvi, pp. 42–51 (January).
Campbell...............	10	1928	ANNALS OF SURGERY, vol. lxxxviii, pp. 1039–1044 (December).
Thompson...............	33	1929	Guy's Hosp. Rep., vol. lxxix, pp. 207–219 (April).
Hennessey..............	22	1929	Jour. Urol., vol. xxi, pp. 193–204 (February).
Total..................	513		

functioning; (4) cases in which aplasia of varying degree has occurred; microscopic study of the remaining aplastic tissue reveals varying amounts of atypical renal tissue, and usually the aplastic kidney is of such rudimentary development that it contains no functional tissue by which body metabolism is aided, and (5) the rare, true, unilateral congenital agenesia, the "unsymmetrical kidney" of Rokitansky and earlier writers. In this last type, no tissue is present on one side that can be identified microscopically as renal parenchyma. It is with this group that this paper will deal.

Many earlier writers described undoubted cases of renal aplasia as cases of unsymmetric kidney, and as a consequence confused the entire subject. Other writers, in reporting so-called new examples, often described cases that had been previously reported and included in earlier series. Thus, numerous series were duplicated in part. I have made an effort to credit the proper author with cases listed by him for the first time or in listing references to other possible examples. Therefore, the number of true examples attributed to various authors will not agree with that of previous papers on this subject.

TABLE II

Reports of Cases Found in the Literature by Author of This Paper

Author	True cases	Year	Journal
Ogle	1	1851	Tr. Path. Soc. London, vol. iii, pp. 382–383 (December).
Barth	1	1853	Bull. Soc. anat. de Par., vol. xxviii, p. 338.
Hillier	1	1864	Tr. Path. Soc. London, vol. xv, pp. 43–48 (February).
Hodge	7	1871	Proc. Path. Soc. Philadelphia, vol. iii, pp. 172–173.
Penrose	1	1889	Tr. Path. Soc. London, vol. lx, p. 161 (May).
Formad	6	1889	Tr. Assn. Am. Phys., vol. iv, pp. 345–378.
Hodenpyl	1	1893	Med. Rec., vol. xliv, p. 155 (July).
Pearce	1	1894	Tr. Path. Soc. Philadelphia, vol. xvii, pp. 141–142 (May).
Lambert	1	1895	Med. Rec., vol. xlviii, p. 169 (August).
Chretien	1	1895	Bull. Soc. anat. de Par., vol. lxx, pp. 660–661 (November).
Bourneville and Tissier	1	1896	Bull. Soc. anat. de Par., vol. lxxi, pp. 49–95 (January).
Sankott	1	1897	Deutsch. Arch. f. klin. Med., vol. liii, pp. 463–474 (June).
Schultze	1	1899	Proc. New York Path. Soc., pp. 282–283.
Power	1	1900	Lancet, vol. i, pp. 25–26 (January).
Deaver	1	1902	ANNALS OF SURGERY, vol. xxxvi, p. 94.
Schloffer	1	1906	Wien. klin. Wchnschr., vol. l, pp. 1515–1519.
Viannay and Cotte	1	1906	Lyon méd., vol. cvi, p. 516 (March).
Bacharach	1	1909	Ztschr. f. Urol., vol. iii, pp. 921–926.
Brunzel	1	1912	Ztschr. f. Chir., vol. cxix, pp. 170–188 (September).
Nemenoff	1	1912	Jour. d'urol., vol. i, pp. 439–440 (March).
Adrian	1	1913	Folia urolog., vol. viii, pp. 95–130 (October).
Judd and Harrington	2	1919	Surg., Gynec., and Obst., vol. xxviii, pp. 446–451 (May).
Brack	1	1921	Ztschr. f. Urol., vol. xv, pp. 389–392.
Leroux and Cornil	1	1921	Bull. et mém. Soc. Anat. de Par., vol. xci, pp. 234–235 (April).
Hannay and Young	2	1924	Brit. Jour. Surg., vol. xi, pp. 780–781.
Huffman	1	1924	Jour. Urol., vol. xii, pp. 379–382 (October).
Sheldon	1	1925	California and West. Med., vol. xxiii, pp. 1569–1571 (December).
Hensel	1	1925	Deutsch. med. Wchnschr., vol. li, pp. 1034–1035 (June).
Petersen	1	1927	Jour. Am. Med. Assn., vol. lxxxix, p. 1778 (November).
Roberts	1	1928	Am. Jour. Surg., vol. iv, pp. 221–222 (February).
Gottlieb	1	1928	Ztschr. f. Urol., vol. xxii, pp. 97–102.
Ceccarelli	1	1928	Jour. d'urol., vol. xxvi, pp. 334–341 (October).
Walter and Krasnoselsky	1	1928	Ztschr. f. urol. Chir., vol. xxv, pp. 424–441.
von Gelderen	2	1928	Beitr. z. path. Anat. u. z. allg. Path., vol. lxxxi, pp. 213–220 (November).
de Massary and Flandrum	1	1928	Bull. et mém. Soc. méd. d. hôp. de Par., vol. lii, pp. 1207–1209.
Bratrud	1	1929	Minnesota Med., vol. xii, pp. 220–222 (April).

Author	True cases	Year	Journal
Hewins..................	2	1929	Urol. and Cutan. Rev., vol. xxxiii, pp. 92–97 (February).
Adams..................	1	1929	New England Jour. Med., vol. cc, p. 1037 (May).
Sharman................	1	1929	Lancet, vol. ii, pp. 63–64 (July).
Pearlman...............	2	1929	Am. Jour. Surg., vol. vii, pp. 836–839 (December).
Fey....................	1	1930	Jour. d'urol., vol. xxix, pp. 66–71 (January).
Carson.................	1	1930	Wisconsin Med. Jour., vol. xxix, pp. 154–156 (March).
Ewell..................	1	1931	Wisconsin Med. Jour., vol. xxx, pp. 92–95 (February).
Total..................	59		

Data derived from the reports in the literature as well as from study of the nine cases seen in The Mayo Clinic can be summarized as follows:

The total number of cases of renal agenesia was 581.

The incidence was 367 in 337,488 cases in which necropsy was performed, or one in 920 post-mortem examinations.

There were 281 males (48.36 per cent.) and 231 females (39.75 per cent.). The sex was not stated in sixty-nine cases (11.87 per cent.).

The left kidney was absent in 318 cases (54.73 per cent.); the right, in 238 cases (40.96 per cent.). Which kidney was absent was not stated in twenty-five cases (4.31 per cent.).

The age incidence was as follows: more than twenty-one years, 381 cases; between the ages of two and twenty-one years, seventy-six cases; between birth and the age of two years, thirty-eight cases; fœtuses, twenty-three cases, and age not stated, sixty-three cases. The average age of male adults was forty-four and four-tenths years, and of adult females, thirty-six and six-tenths years. The average age of the males who were between the ages of two and twenty-one years was eleven and six-tenths years, and of the females, fourteen and four-tenths years. The oldest man was aged eighty-eight years, and the oldest woman, seventy-six years.

The kidney was smaller than normal in twenty-seven cases (4.64 per cent.); normal, in thirty-one cases (5.33 per cent.); enlarged, in 308 cases (53 per cent.), and the size was not stated in 215 cases (37 per cent.). The exact average measurements in forty cases were 13.3 by 6.6 by 4.5 centimetres (normal, 10 by 6 by 3.5 centimetres). The average weight in eighty-seven cases was 279.63 grams (normal, 150 grams).

The ureter was absent on the side on which the kidney was absent in 297 cases (51.11 per cent.); of these, the left kidney was absent in 182 and the right in 115 cases.

Kidney, ureter and renal vessels all were absent in 116 cases (19.96 per cent.).

On the side on which the kidney was absent the ureter and the renal vessels were absent in nineteen cases (3.27 per cent.).

The ureteral orifice in the bladder was absent on the side on which the kidney was absent in 133 cases (22.89 per cent.).

One ureteral orifice and the corresponding part of the vesical trigone were absent in forty-four cases (7.57 per cent.).

The ureter on the affected side was obliterated, remaining as a cord of connective tissue in eleven cases (1.88 per cent.). It was obliterated in the cephalic portion only in twenty-three cases (3.95 per cent.).

The ureter was completely patent in eight cases (1.37 per cent.).

The site of the absent ureteral vesical orifice was replaced by a diverticulum of the bladder in five cases (0.86 per cent.). The ureter of the solitary kidney emptied into the opposite ureteral orifice in three cases (0.51 per cent.). There were two patent ureteral vesical orifices in twenty-one cases (3.61 per cent.). There were two patent ureteral vesical orifices from the solitary kidney in four cases (0.68 per cent.). The ureter from the solitary kidney was duplicated in four cases (0.68 per cent.). The ureteral vesical orifice was in the median line of the bladder in eight cases (1.37 per cent.). The ureter opened into the seminal vesicle on the side of the absent kidney in sixteen cases (2.75 per cent.).

The condition of the solitary kidney was as follows: normal, in 281 cases (48.36 per cent.); diseased, in 179 cases (30.80 per cent.), and not stated, in 121 cases (20.82 per cent.).

Death was from diseases unrelated to the genito-urinary tract in 400 cases (68.84 per cent.); from diseases of the kidney and ureter in 110 cases (18.93 per cent.); and the cause of death was not stated in seventeen cases (2.92 per cent.). When the reports were made, fifty-four patients (9.29 per cent.) were alive. Death of those who succumbed to diseases of the solitary kidney and ureter was caused by nephrolithiasis in twenty-four cases; from ureterolithiasis in sixteen cases; from chronic nephritis in twelve cases; from pyelonephritis and pyonephritis in twenty-seven cases; from renal tuberculosis in four cases; from hydronephrosis in eleven cases; from infarction in one case; from carcinoma of the kidney in one case; and from nephrectomy in twelve cases. The solitary kidney was mistakenly removed for ectopic kidney in four cases; for pyelonephritis in three cases; for hydronephrosis with infection in two cases; for traumatic rupture in two cases, and the condition for which the kidney was not removed was not stated in one case.

Congenital agenesia of one kidney was recognized by cystoscopic examination, urography, and so forth, in forty-one cases (7.05 per cent.); at a preceding operation, in eighty-three cases (28 per cent.); at necropsy, in 439 cases (75.55 per cent.) and how it was recognized was not stated in eighteen cases (3.09 per cent.).

The suprarenal gland was absent on the side on which the kidney was absent in sixty-six cases (11.34 per cent.); in twenty-eight of these the right side was affected, and in thirty-eight, the left. The suprarenal glands were atrophied on the side on which the kidney was absent in four cases (0.68 per cent.); they were hypertrophied in thirteen cases (2.23 per cent.), nor-

TABLE III

List of Congenital Anomalies Mentioned in the Literature as Being Associated in Cases of Renal Agenesia

Anomalies unrelated to kidney	Cases	Anomalies unrelated to kidney	Cases
Uterus bicornis	51	Absent testis, seminal vesicles, vas deferens and ejaculatory duct	4
Uterus unicornis	60		
Uterus didelphys	4	Absent vas deferens and seminal vesicle	14
Uterus bilocularis	2		
Uterus subseptus	1	Incomplete male genitalia	1
Uterus duplex with vaginal septum	4	Absent ejaculatory duct	1
Uterus bifidus	1	Atresia of anus and urethra	1
Malformation of the uterus	1	Atresia of anus with hypospadias	1
Absent uterus and vagina	11	Atresia of anus	3
Rudimentary uterus, tubes, ovaries	4	Absent anus, rectum, urethra	1
Defects of tube	1	Absent rectum	2
Only fimbriated end of tube	12	Malformation of rectum	1
Absent tubes, ovaries, ligaments	10	Atresia of œsophagus	1
Absent round ligaments	3	Talipes equinovarus	3
Atrophic ovary and cervix	5	Cleft palate	4
Atrophic tube	2	Harelip	5
Absent vagina	1	Meningomyelocele	3
Abnormal insertion of tube	1	Hydrocephalus	5
Malposition of ovaries	8	Microphthalmus	1
Undescended ovaries	5	Hemicephalus	1
Vagina with one side only	1	Anencephalus	1
Absent female internal genitalia	8	Absent patella; defect in occipital bone	1
Dermoid cysts of ovary	2	Idiocy	3
Dermoid cyst of tube	1	Malformation of liver	2
Tube inserted into vagina	3	Malformation of duodenum	1
Atresia of anus and vagina	2	Right lung with four lobes	1
Atresia of vagina with no labia minora	2	One eye absent	1
Stenosis of cervix of uterus	1	Absent nose	1
No external female genitalia	1	Ascending colon with a mesocolon	2
Atresia of hymen	2	Rectosigmoid crossing over to right side of pelvis	2
Atrophic broad ligaments	1		
Tubal pregnancy	2	Congenital, complete, indirect inguinal hernia	4
Situs viscerum inversus	1		
Ectopia of bladder	4	Fœtus with no umbilical artery	1
Absent bladder	1		
Atrophy of testicle, seminal vesicles and vas deferens	16	Total	338
		(58.2 per cent of 581 cases)	
Atrophy of vas deferens, seminal vesicles and epididymis	10	Anomalies of renal blood supply	Cases
		Abnormal origin of renal arteries	55
Atrophy of testis only	6	Abnormal emptying of renal vein	49
Atrophy of one lobe of prostate gland	3	Multiple renal arteries	39
Cysts of seminal vesicles	8	Total	143
Undescended testis	4	(24.6 per cent. of 581 cases)	

mal in 129 cases (22.20 per cent.), and their condition was not stated in 369 cases (63.50 per cent.).

A list of associated congenital anomalies is given in Table III. In order clearly to understand the mechanism of their occurrence, the embryologic

development of the kidneys and genitalia of both sexes must be reviewed briefly.

In human beings three sets of excretory organs develop in embryonic life. The first, or pronephros, is of importance only in that it furnishes the ducts of the second organ, or mesonephros. Aside from this, the pronephros disappears entirely. The mesonephros, or Wolffian body, gives origin in the male, from caudad to cephalad, to the following structures: seminal vesicles; ejaculatory ducts, vas deferens, and efferent tubules of the testes. Two Müllerian ducts arise about the same time, and in the female, their cephalic, divided portions give rise to the Fallopian tubes, whereas their fused, caudad portions form the uterus and vagina. The Müllerian ducts in the male form no important structure. The testes or ovaries arise separately from the adjacent genital ridge. The ureters arise as buds from the caudal ends of the Wolffian ducts, near the cloaca. The third organ, or metanephros, arises as a bud from the preëxisting mesonephros. The adult kidney develops from this third structure. The suprarenal glands are not intimately connected with this development, and hence are rarely absent even if the kidney and other related unilateral structures are absent. Four theories have been advanced by Fortune as to the causation of this anomaly: (1) The metanephric bud may fail to appear in spite of a normally preceding mesonephros; (2) the metanephros may appear, but may undergo early regression; (3) the meso- nephros may be imperfectly developed, and (4) the pronephros may fail to develop, and therefore the mesonephros does not grow. The greater incidence of malformation of the genitalia in the female associated with congenital unilateral renal agenesia can now be understood, because the Müllerian duct is a later development than the Wolffian duct, and as a consequence its chance of undergoing malformation is greater. In females the commonest malforma- tions are those of the caudal portions of the Müllerian ducts, or the uterus and vagina, whereas the cephalic portions, or Fallopian tubes, are usually less involved. In the male the most advanced malformations of the genitalia occur about the bladder, and commonly diminish toward the testes. This fact supports the theory that a disturbance in the caudal portion of the embryo, involving the Wolffian duct, explains these anomalies. Associated malformations of the body outside the genito-urinary tract, although they may occur and may be extensive, are not common. From data obtained in the literature, it appears that in 58 per cent. of 581 examples of renal agenesia there were associated anomalies of varying degree. Associated malformations were present in 89 per cent. of the females and in 41 per cent. of the males. Usually the associated defects of the genitalia are so slight that they do not cause comment on general examination, and as a consequence the presence of only one kidney is not suspected at the time of general examination.

The fact that in 381 cases (65.5 per cent.) of congenital unilateral renal agenesia reported in the literature adults were affected, and that their average age was about forty years, together with the fact that 68.3 per cent. of the

patients died of diseases totally unrelated to the genito-urinary system, indicates that the condition is not a serious menace to life. On the other hand, it must be remembered that these subjects offer poorer prognosis when disease of the genito-urinary tract is present. The patients do not tolerate extensive operations on the urinary tract, and hence the most conservative procedure compatible with arresting the disease must be instituted. With the excellent diagnostic procedures now available, the diagnosis of this anomaly in the genito-urinary system is not difficult. However, it must be remembered that two patent ureteral orifices do not necessarily rule out the possibility of unilateral absence of a kidney. Twenty-five examples have been collected from the literature in which two patent ureteral vesical orifices were present, associated either with double ureter of a solitary kidney or with patent ureter on the side on which one kidney was absent.

Nine cases of congenital unilateral renal agenesia were found in the course of 6,349 post-mortem examinations done at The Mayo Clinic, or an incidence of one to 705. The cases are reported briefly.

SUMMARY OF NINE CASES SEEN IN THE CLINIC

CASE I.—A woman, aged thirty-three years, died of generalized sepsis. The right kidney, its vessels, and ureter were absent. The right suprarenal gland, and the right ovary and tube were also absent. The left kidney weighed 310 grams and measured

FIG. 1.—Case IV. The solitary right kidney with ureter and bladder.

14 by 7 by 4 centimetres. Grossly, the left kidney was studded with miliary abscesses which on microscopic examination were revealed to be of pyæmic, staphylococcic origin.

CASE II.—A man, aged thirty-seven years, died of a disease totally unrelated to anomaly of the kidney. Only the left kidney was absent. The ureter and vessels remained as cords of connective tissue. Both suprarenal glands were present. The genitalia were normal. The right kidney weighed 362 grams and measured 14 by 7 by 5.5 centimetres; otherwise it was normal on gross and microscopic examination.

CASE III.—A fœtus, male, weighed 2,800 grams. The left kidney and ureter were absent. Both suprarenal glands were present. The genitalia were normal. The right kidney weighed 16 grams and appeared normal both grossly and microscopically.

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CASE IV.—A man, aged fifty-four years, died of syphilis of the central nervous system and acute pyelonephritis. The left kidney, the ureter, and vessels were absent. Both suprarenal glands were present and the genitalia appeared to be normal. The right kidney weighed 320 grams and measured 13.5 by 7.5 by 5 centimetres. Marked pyelonephritis was present on both gross and microscopic examination. (Fig. 1.)

CASE V.—A female infant weighed 2,716 grams. The left kidney was absent. Both suprarenal glands were present. There was a uterus unicornis, absence of the right patella, bilateral talipes equinovarus, moderate hydrocephalus, slight meningomyelocele, and a left diaphragmatic hernia. The right kidney weighed 12 grams and appeared normal on both gross and microscopic examination.
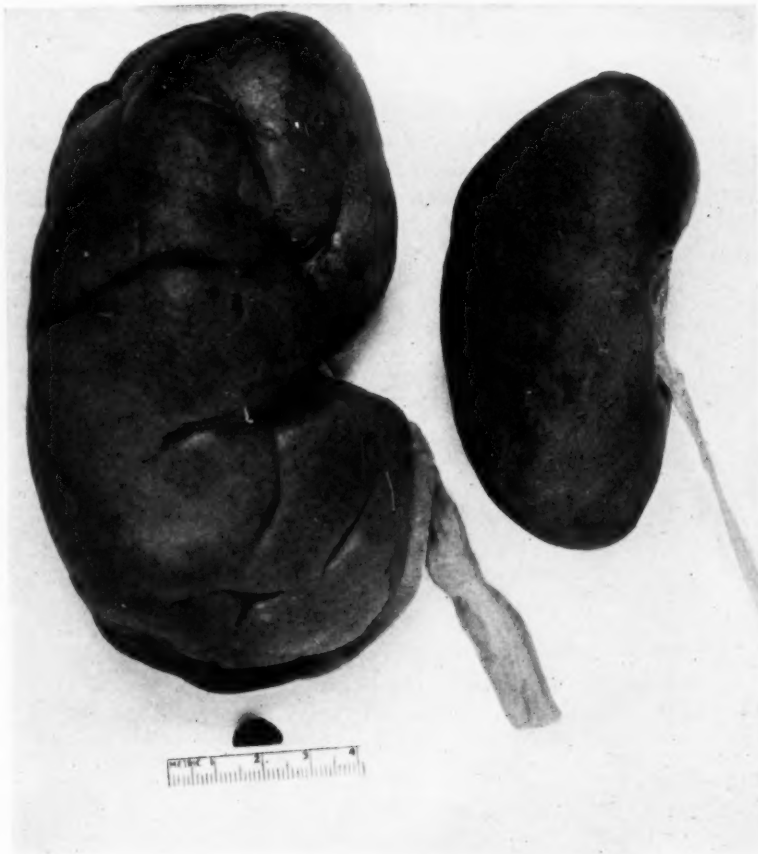
FIG. 2.—Case VII. The enlarged solitary right kidney compared to a normal kidney from another patient.

CASE VI.—A woman, aged thirty-three years, died of a disease totally unrelated to the kidney. The left kidney was absent but its ureter and vessels were present. Both suprarenal glands were present. The right tube was inserted on the uterus in an abnormal manner. The right kidney weighed 200 grams and measured 12 by 6 by 4.5 centimetres. It appeared normal both on gross and microscopic examination.

CASE VII.—A man, aged fifty-six years, died of a disease totally unrelated to the urinary tract. The left kidney, its vessels and ureter were absent. Both suprarenal glands were present. The right kidney weighed 505 grams (normal, 150 grams), and measured 15 by 8 by 6.5 centimetres. It appeared normal both grossly and microscopically. (Fig. 2.)

CASE VIII.—A man, aged fifty-five years, died of a disease totally unrelated to the urinary tract. The left kidney, its ureter and vessels were absent. Both suprarenal glands were present. The left testis was moderately atrophied. The right kidney weighed 270 grams and measured 12 by 7.5 by 5 centimetres; otherwise it appeared normal both grossly and microscopically. (Fig. 3.)

FIG. 3.—Case VIII. The right kidney, its ureter, renal vessels arising from the aorta, and the bladder. The absence of a corresponding left renal artery arising from the aorta, the poorly developed left portion of the vesical trigone, and absence of the left ureteral vesical orifice may be noted.

CASE IX.—A boy, aged two years, died of hydronephrosis with infection and subsequent uræmia. The left kidney, its ureter and vessels were absent. One renal vein was represented by a cord of connective tissue. Both suprarenal glands were present. The right testis was undescended. The right kidney weighed 36 grams and measured 6 by 3 by 2.5 centimetres. On gross and microscopic examination there was seen to be advanced staphylococcic pyelonephritis as well as the marked hydronephrosis with infection.

SUMMARY

The literature concerning congenital unilateral renal agenesia has been reviewed, and reports of 572 cases have been found, fifty-nine of which have not been cited by any reviewer before me. Reports of nine cases seen at the clinic are given for the first time. Thus, 581 cases are considered in the paper. References to forty-nine questionable cases have been appended in a separate bibliography, these have not been verified, and are not included in the textual or tabular consideration.

APPENDIX

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THE INJECTION TREATMENT OF VARICOSE VEINS

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The cases that form the basis for this report have been under treatment in the varicose vein clinic of the Fourth Surgical Division of Bellevue Hospital. The work was started in September, 1929, and has continued without interruption up to the present time. Up to September 1, 1931, 848 cases have been treated, with a total of 3,532 injections.

As to the various solutions used, together with the history attached to each, in 1923, K. Linser,[1] in Tubigen, first began the use of 20 per cent. sodium chloride solution as a sclerosing agent in treating varicose veins. At about the same time, Sicard,[2] in France, was using 20 to 40 per cent. sodium salicylate solution for the same purpose. It is really to the work of these two men that the modern treatment is indebted and from the time of their first reports the popularity of the treatment has risen by leaps and bounds. McPheeters,[3] in this country, was the first to become active in this line of work and his monograph on the subject is a very complete and lucid discourse on the treatment as he uses it today. Since McPheeters' original article appeared, numerous others by various authors have appeared, all agreeing as to the efficiency of the treatment and differing only in their choice of solutions and in certain minor details of the technic of administration.

Fifty per cent. dextrose solution, a mixture of 50 per cent. dextrose and 30 per cent. sodium chloride,[8] and a mixture of quinine and urethane are the three other solutions that have been most extensively used, and these five may very properly be considered as the only ones worth discussing at present.

We have used all five of these solutions at various times with the idea of arriving, if possible, at the solution which to us gave the best results. The original solution that we used was a 20 per cent. solution of sodium chloride on a group of eighty cases in doses of five to six cubic centimetres; 270 injections were given. Definite thrombosis occurred in 90 per cent. of injections and failed to thrombose in 10 per cent. Following this, we used sodium salicylate solution in 30 to 40 per cent. strength, the dose being four to five cubic centimetres at each injection. This was given for a total of 845 injections on a group of 250 cases. Definite thrombosis occurred in 95.5 per cent. of injections and failed to thrombose only in 4.5 per cent. Fifty per cent. dextrose and 30 per cent. sodium chloride solution in doses of five to ten cubic centimetres was used next. Three hundred and forty-two injections

were given on 100 cases, with thrombosis in 92.1 per cent. and no thrombosis in 7.9 per cent. Quinine and urethane was then used. The solution as we have given it is put up in ampules by various commercial firms and is readily obtainable. The dose is one-half to two cubic centimetres, depending upon the size of the vein, although our first dose is limited to one-half cubic centimetre to be sure of the patients' tolerance to quinine. Two thousand and seventy-five injections of quinine and urethane were given to 415 patients. Thrombosis occurred in 94.8 per cent. of injections and no thrombosis in 5.2 per cent.

It will be seen from the above that the two solutions which gave the highest percentage of thromboses were the sodium salicylate and the quinine and urethane. The 30 to 40 per cent. sodium salicylate solution has one distinct disadvantage and that is the very severe cramp-like, burning pain which occurs immediately upon injection and lasts for two or three minutes. This has been commented upon by various observers[7] and I for one have been very much impressed by the real severity of the pain. Patients will actually moan and cry out while it lasts and will describe it as the most acute and piercing pain they have ever had. In many instances, patients have refused a second injection of the salicylate solution because of the severe pain resulting from the first. On the other hand, the pain associated with the injection of the quinine and urethane is practically nil, and the percentage of positive thromboses is about as high as in the salicylate series. Because of this I have come to accept the quinine and urethane as the solution of choice for the injection treatment. There is no pain, the resulting thrombosis is always there and I have yet to observe any untoward reactions. A few more injections may be necessary than with the salicylate solution as the thrombosis may not be as extensive, but this is more than compensated for by the absence of the immediate local pain which is so severe in all instances.

The technic as followed by us is relatively simple. A stool is placed upon the examining table with the patient sitting upon the stool. This puts the legs in the pendent position, whereby the veins are distended and thus easiest to deal with. If the veins to be injected are in the thigh the patient is asked to stand upon the examining table and then is allowed to sit down at the conclusion of the injection. The site chosen for the injection is painted with a $3\frac{1}{2}$ per cent. tincture of iodine. The first injection is usually given in the lowest veins first, as it must be remembered that the blood flow in varicose veins of the dependent leg is in the reverse direction to normal and if the injection is given too high the resulting dilution of the sclerosing solution will be too great. This reverse flow of the blood has been very well shown by McPheeters by fluoroscopical studies following the injection of lipiodal into the vein. A short bevel twenty-five-gauge needle, extremely sharp, on a well-fitting two-cubic-centimetre Luer syringe completes the armamentarium. At the first injection, one-half cubic centimetre of quinine and urethane solution is injected and subsequently one to two cubic centimetres,

depending upon the size of the vein to be injected. Injections are given once a week. Following the injection a small sterile compress is applied over the site of injection and firm pressure is made for two or three minutes to prevent leaking of the solution into the surrounding tissues through the needle hole in the wall of the vein. The compress is then held in place with two adhesive strips and the patient is told to remove it the following day. No tourniquets are used and no bandages are applied. We have tried them both and could not see that they aided the end-result in the least. Neither do we place the patient in a recumbent posture during the injection as some have advised so as to empty the vein and thus bring the sclerosing solution in more intimate contact with the vein wall. We tried this for a while and could see no improvement in our end-results. Following the injection the patient is assisted from the examining table and allowed to go home.

The most important point in the technic is in using care that none of the solution is injected outside of the vein. When the needle is first introduced into the vein, we advise withdrawing the barrel of the syringe a short distance so as to allow blood to flow back, thus assuring one that the needle is well in the vein. This is repeated when about half of the solution has been injected, as occasionally the needle point will penetrate the distal wall of the vein while the injection is taking place, unless care is used.

If some of the solution escapes into the perivascular tissues a slough may result. The amount of sloughing that occurs varies with the amount of solution that has escaped into the tissues and to a certain extent upon the individual patient. We have seen certain cases in which it was known at the time of the injection that some of the solution had been injected into the perivascular tissues and yet in these cases no slough occurred. A certain amount of redness and induration resulted but no real destruction of tissue. On the other hand, we have seen other patients where we also knew that a similar amount of solution was injected outside of the vein and a definite slough resulted. The size of the slough varies greatly and is a factor in determining the length of time it will take for complete healing to ensue. All sloughs are characterized by the relatively great length of time it takes for separation and healing to take place. It is not uncommon for some to take four or five months to heal. We do not feel that surgical excision is of any value, as we could not see any hastening of healing in the few that we so treated. We simply use a local wet dressing of boric acid at first, followed by boric ointment and then occasionally balsam of peru to stimulate granulations. Fortunately, in our experience, the sloughs have not been frequent, but in a large series of cases where a number of men have given the injections a certain number cannot be avoided. We do not look upon them with any feeling of anxiety, as they very seldom incapacitate the patient, and their principal disadvantage is the long time required for healing. Much has been said about some solutions being less likely to cause sloughs than others. With this we cannot agree. Our percentages of sloughs have been just the same whether the solution used was 20 per cent sodium chloride, 40

per cent. sodium salicylate, quinine and urethane or a mixture of dextrose and sodium chloride. We cannot convince ourselves otherwise.[6] Any solution that is sclerotic enough in its action to cause a thrombosis in the vein will also chemically destroy other subcutaneous tissues if it comes in contact with them in sufficient amount. Fifty per cent. dextrose we will admit does not come in this group, but on the other hand its sclerosing action is so definitely inferior to the other solutions that this in itself explains its lack of destructive effect upon the perivenous tissues.

Two or three days following the injection an area of redness and induration occasionally occurs in the vicinity of the vein injected. This sometimes is rather extensive and may become the cause of temporary disability. It is a periphlebitis due to the inflammatory reaction resulting from the chemical irritation of the vein wall, and is to be carefully differentiated from the slough. These areas of periphlebitis usually subside in two or three weeks spontaneously, and the comfort of the patient may be enhanced by local wet dressings of boric acid solution and rest of the affected limb. The percentage of periphlebitis following injection has been about the same with all of the solutions used. We are sure that it is as frequent with the quinine and urethane as with the others, although it has been suggested otherwise by some observers. The same rule applies here as with the sloughs, namely, that if the solution has a strong sclerotic action the likelihood of periphlebitic reaction is the same regardless of whether it happens to be sodium chloride, sodium salicylate or quinine and urethane. The condition, however, is never serious; it always subsides but it may be a cause of anxiety to the patient, due to the pain and disability resulting.

The most dramatic cases are those in which a varicose ulcer, frequently of long standing, exists. In this series there were ninety-four ulcer cases. Here the ulcer will frequently heal in a very short time. We have several cases where the ulcer had been present for over twenty years and where complete healing occurred within six weeks. The ulcer itself is entirely disregarded in the treatment, no special ointment is applied nor is any particular local treatment used. Usually Lassar's paste is our application of choice, but there is no particular rational for this. It is used simply as a protective dressing. We feel that as the cause of the ulcer is entirely circulatory, it is rather superfluous to attempt local treatment. Our results have justified this viewpoint as we have been successful in healing about 90 per cent. of the varicose ulcers that have come under our care. Those that have a coëxistent brawny induration of the leg surrounding the ulcer have been confined in bed, either in the hospital or at home, for two or three weeks to allow the brawny area to soften and make it possible to find the veins therein. These veins can very often not be seen but must be found by palpation. Ulcers that have been healed have remained healed, at least as far as one can follow them in a hospital clinic.

The main point that we would like to emphasize is that the treatment should be technically simple and we have not found that any deviation from

this rule has improved the results. A single injection with the patient upright, extreme care being taken to see that the needle is in the vein, is all that is necessary. If in doubt as to whether one is in the vein, do not inject, but select another vein. Then a simple gauze dressing and that is all. Local treatment of an ulcer is unimportant, as it is in the case of the slough. Simple cleanliness with antiseptic dressings is all that is necessary. The ulcer will heal if all the varicose veins are thrombosed and nature will separate the slough and healing by granulation will ensue.

In a recent article by De Takats,[4] he states that the salicylates and quinine are poorly tolerated by many patients. With this we cannot agree as in over 800 injections with salicylate, and over 2,000 injections with quinine we have seen only one constitutional reaction and that was one from quinine. In this case the patient became faint and pallid and then vomited, but was entirely normal again in about ten minutes and was able to return home. We have never seen any other reactions of any moment. We have used quinine and urethane routinely now for over one year and the absence of pain, together with the small amount of solution necessary and the excellent results obtained, cannot help but impress us that it is the solution of choice. The mixture of 50 per cent. dextrose and 20 per cent. sodium chloride solution[8] is undoubtedly of value but we have seen a number of failures with its use even when the various precautions suggested by McPheeters[5] were observed, and there is undoubtedly a definite pain associated with its use although not as severe as with the salicylate. We feel that an attempt has been made by some authors to make the injection method seem unduly technical. It is simple and should remain simple. There is no reason why any physician cannot use it with excellent results if he is careful in injecting and uses sharp needles and well-fitting syringes.

As far as the question of recurrences of the varicose veins is concerned not much has appeared in the literature. The results of Howard, Jackson and Mahon,[9] as reported in March, 1931, show an almost prohibitive percentage of recurrences. Our experience does not in any way bear out their findings. I have had an opportunity of seeing and following large numbers of these patients for the past three years and the number of recurrences that I see is exceedingly small. Practically all of the hospitals in New York City are using the injection method of treatment today and there are only a very few recurrences from other hospitals coming to our clinic. If the average percentage of recurrences were any way near as high as the above authors report, we would be flooded by cases with recurrences not only from our own clinic but from the other hospitals as well. We will admit that if one is not careful to thrombose the main internal saphenous trunk in the thigh, providing it is varicosed at all, recanalization of the veins in the leg below is more likely to occur. Frequently the fact that the internal saphenous vein is involved may be overlooked, as it occasionally will only be palpable when in the pendent position and not be visible at all. Careful search by palpa-

tion and inspection should be made for the main trunk of the internal saphenous vein and thrombosis obtained by injection.

We do find that a certain number of varicose vein patients as such have a definite tendency to form other varicose veins later on. These new varicose veins, however, should not be confused with veins that have already been thrombosed. I have seen a number of cases such as this, where new varicose veins have appeared a year or so after the careful thrombosis of all existing veins. Careful examination and a follow-up at more frequent intervals will clearly show that the new varicose veins appearing are not recurrences but are new veins becoming varicosed due to the same tendency in the individual that was responsible for the formation of the first group of varicose veins.

The contra-indications to the treatment are, in main, two: (1) An active bacterial thrombophlebitis; and (2) any previous thrombosis of the deep veins of the extremity. Otherwise, we feel any case may be safely injected. Pregnancy is not a contra-indication except in the later months.

The accompanying chart is self-explanatory. It gives the number of injections with each solution, the percentage of thromboses resulting, together with the number of sloughs.

Observations on 848 Patients with Varicose Veins Treated by the Injection Method

	Total Injections	Good Thromboses	Percentage of Good Thromboses	Poor or No Thromboses	Percentage of Poor or No Thromboses	Sloughs
Quinine and Urethane	2,075	1,969	94.8	106	5.2	24
30-40% Sodium Salicylate ..	845	807	95.5	38	4.5	11
20% Sodium Chloride	270	244	90	26	10	8
Dextrose and Sodium Chloride	342	315	92.1	27	7.9	3

Total number of ulcer cases treated—94.
Total number of ulcer cases healed—84.
Total number of ulcer cases not healed—10.
Emboli—none.

As I stated before, we are definitely of the opinion that in actual practice many of the refinements in the technic as advocated by some observers are not borne out. In theory, they are undoubtedly correct, but practically, we have not been impressed with their advantages. Whether the vein is collapsed or not at the time of injection has not altered the results. It would seem true that an intimate contact of the sclerosing solution with the vein wall would be enhanced by emptying the vein, but in practice over controlled cases I could not see any difference in the end-results. Tourniquets and bandaging we have discarded after a very thorough trial.

We have never seen a case of embolus following the injection treatment. This, at present, seems to be a universal finding and undoubtedly any embolic phenomenon can be practically ruled out as a possible complication of this method of treatment.

CONCLUSIONS

(1) Eight hundred and forty-eight patients with a total of 3,532 injections are reported on.

(2) Quinine and urethane is our solution of choice because of the excellent results obtained, the small quantity of solution necessary, and the ease of administration with a small syringe.

(3) The technic of the treatment is simple and should remain simple. It should not be complicated by unnecessary refinements.

(4) In our experience recurrences are infrequent and should not be confused with the formation of other new varicose veins.

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SODIUM MORRHUATE AS A SCLEROSING AGENT IN THE TREATMENT OF VARICOSE VEINS

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FROM THE VARICOSE VEINS CLINIC OF THE HOSPITAL FOR JOINT DISEASES

Although the superiority of the injection method *versus* other forms of treatment of varicose veins is no longer an issue, there are several complicating features that have prohibited its being termed the ideal method. The chief points of dissatisfaction have been the following:

(1) The pain or cramp resulting from venospasm at the time of injection.

(2) The destruction of tissues as a result of improper technic or extravasation.

(3) The toxicity and individual idiosyncrasy exhibited to the various drugs.

(4) Temporary disabling periphlebitis.

(5) Occasional failure to respond to treatment.

We believe that the employment of the sodium-morrhuate solution in a large measure obviates all these difficulties, and we feel that there is now at our disposal a drug which more closely approaches the ideal than any other chemical sclerosing agent used for this purpose heretofore.

This paper is based upon a study of 200 cases and about 600 injections given with sodium morrhuate both in private and clinic practice. While the injection treatment of varicose veins is a safe procedure in experienced and careful hands, our observations lead us to believe that there is a higher mortality than that given in the literature, and that the mortalities are not due to pulmonary emboli but to infections contracted as a result of sloughs, and other complications resulting from poor technic and treatment of contraindicated cases. The technic and contraindications have been so well described in the medical literature in recent years by various writers that it is needless for us to repeat them. Notwithstanding the fact that the solutions used at present, such as sodium chloride, or sodium chloride in combination with glucose, dextrose, invert sugar, *etc.*, or sodium salicylate, or its sugar combinations, or quinine hydrochloride and urethane are strongly advocated by many, we are of the opinion that the ideal solution has not as yet been found.

An ideal solution would be one which would produce neither pain nor cramp following its injection, which would have no systemic action, and which would be least likely to produce a slough if injected outside the vein. And, above all, it must induce a firm, lasting and not painful obliteration of the injected vein. According to our experience sodium morrhuate is the closest approach to the ideal solution.

Sodium morrhuate was first made by Sir Leonard Rogers[1] for use in surgical tuberculosis. It was later produced by R. A. Cutting,[2] and he

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described the details of its preparation together with physical and chemical properties. The applicability of sodium morrhuate for varicose-veins treatment first occurred to P. B. Kittel, who administered a 3 per cent. sodium-morrhuate solution intravenously for the treatment of surgical tuberculosis, and noticed that it frequently caused a hardening and occlusion of the injected vein.

Sodium morrhuate is a sodium salt of a fatty acid extracted from cod-liver oil. It is a yellow powder, which has a greasy, soap-like feel, and an odor that is characteristic of cod-liver oil. It is readily soluble in water and produces a clear, light amber-colored solution which foams on agitation. The substance in powder form deteriorates rapidly but is more stable when dissolved in water and sealed in air-tight containers. The preparations we used are a 5 per cent. aqueous solution of sodium morrhuate to which 0.5 per cent. phenol has been added as a preservative and one to which about 0.5 per cent. benzyl alcohol has been added. The manufacturers of the latter claim that the benzyl alcohol acts as a preservative, as an anæsthetic and antispasmatic. We maintain that the benzyl alcohol does not produce anæsthesia, nor does it prevent cramp, and it is not necessary in this solution or in any other solution used in the injection treatment of varicose veins. Cutting states that it deteriorates and loses its therapeutic potency after a period of two weeks. Our experience does not verify his contention.

Effects of Injections.—No systemic or toxic symptoms were observed, nor any immediate discomfort, pain or cramps noticed in any of our cases following the injection of sodium morrhuate. We have given at one sitting as high as ten cubic centimetres of the 5 per cent. solution without any discomfort to the patient. This dose is extreme and is rarely ever indicated. The dose necessary to produce a sclerosing of the varix is proportional to the size of the vein. In small or medium-sized veins, one to two cubic centimetres of the 5 per cent. solution are sufficient; in large veins, three to five cubic centimetres are necessary. While Kittel and Higgins[3] advise multiple injections at one sitting, we have seldom done so except in very small veins. We prefer to give single injections at twenty-four- or forty-eight-hour intervals, depending upon the response of the patient to the drug. As stated above, the injection produced neither pain, cramp nor any discomfort whatsoever. Occasionally, after a three to five cubic centimetre injection, some patients complained of a tingling sensation at the site of injection, but not of sufficient degree to cause any appreciable discomfort. A few minutes following the injection the vein begins to harden and this sclerosing extends below the site of injection for about two to four inches, depending upon the size of the vein and its response. About twenty-four hours later the vein is hard and firm and not very tender to touch, there being little or no periphlebitis, so commonly seen following the employment of other solutions. The skin about the injected vein assumes a light bronze color, which discoloration disappears in a short time.

Sodium morrhuate is not destructive to tissue. Kittel has injected 0.5

cubic centimetres of the 5 per cent. solution into his own arm without any ill effects, other than a slight local tenderness. The similarity of the struc- ture of the tunica vaginalis and the vein walls led one of the writers (Tunick) to inject sodium morrhuate into a hydrocele. (Courtesy of Dr. Paul Aschner, Visiting Urologist to Hospital for Joint Diseases.) A fairly large hydrocele was tapped and then injected with two cubic centimetres of the 5 per cent. solution. It did not produce any sloughing or destruction of tissues. There was a slight testicular tenderness which lasted about ten days. We believe this solution may prove of value in the treatment of hydroceles.

P. McEvedy[4] has employed sodium morrhuate for obliteration of simple ganglia of the wrist, and he reports extremely satisfactory results. He employed 0.5 to 2 cubic centimetres of the 5 per cent. solution and he has never seen any sloughing nor other damage to the tissues following its use. On Dr. H. Finkelstein's service at the Hospital for Joint Diseases a series of ganglia and bursæ have been injected. Thus far, the cases injected show no evidence of tissue damage and the results appear promising. From these reports and observations we are led to conclude that the injection of sodium morrhuate will not produce a slough, should a perivenous infiltration occur. However, it is essential that the same precautions be observed in injecting the sodium-morrhuate solution as when employing a drug that will produce a slough.

Technic of Injection.—Kittel and Higgins claim that the best results are obtainable when the injection is made into a fully distended vein, and they therefore inject the patient while in the upright position. Our own observations lead us to believe that a full distention of the vein is not necessary, not even preferable. The standing position may be of advantage in the smaller veins, but in the large veins it is advisable to elevate the limb to empty the vein of some of the blood, and then apply digital pressure or a tourniquet above the point of injection. Here pressure should be maintained for some two or three minutes after the injection so as to prevent dilution of the drug by the back flow of blood from above. Our results in injecting sodium morrhuate into the small veins, so-called spider bursts, or skyrockets, have been better than those obtained with any other sclerosing solution.

In treating the smaller veins it is advisable to first immerse the ampule in warm water. This lowers its viscosity, and consequently permits the use of a finer-gauge needle. After the injection a small pledget of sterile gauze is applied over the vein puncture and is secured by a small strip of adhesive tape. Tight bandaging is not necessary. The needle puncture seals up rapidly. However, it is advisable to inspect the wound and see that there is no bleeding at the punctured site before the patient is permitted to leave. Patey's[5] experiments on rabbits have shown that an injection of one cubic centimetre of 5 per cent. sodium morrhuate into the ear veins produces results similar to those obtained by the injection of 30 per cent. sodium salicylate, *i.e.*, a general dilatation of the vessels of the ear, followed by the rapid for-

mation of an intravenous clot. Microscopically, degenerative changes can be detected in the vein wall, and an acute inflammatory reaction in the surrounding tissue. He also found that sodium morrhuate was not so certain in thrombotic action as 30 per cent. sodium salicylate, and that it definitely is not a blood coagulant.

CONCLUSIONS

(1) Sodium morrhuate does not produce cramp or pain following its injection

(2) It is apparently not destructive to tissues and therefore least likely to produce tissue necrosis or slough if injected outside the vein.

(3) It produces a firm obliteration of the vein with very little periphlebitis.

(4) It is not toxic.

(5) The dose of it is one to five cubic centimetres of the 5 per cent. solution, the average dose being two cubic centimetres.

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VARICOSE VEINS AND THEIR TREATMENT

WITH A STUDY OF THREE HUNDRED FIFTY-FOUR CASES

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THERE is still considerable skepticism as to the efficacy of the injection treatment, due primarily to the lack of understanding of the pathology of enlarged veins and the process which follows the injection of sclerosing solutions. It is to emphasize this phase of the subject that this paper is written. A series of 354 consecutive cases treated by the writer in the clinic of the First Surgical Division of the New York Hospital, service of Dr. James M. Hitzrot, will be the basis of the deductions made.

Pravaz, in 1851, was responsible for the introduction of the hypodermic syringe into Europe and the popularizing of its use. Following the injection of heavy metal solutions into veins he noticed that they thrombosed and could not be entered the second time. During the next half century sporadic efforts were made to obliterate enlarged veins by the injection of sclerosing solutions. The method, however, repeatedly fell into disuse. Only in the past twenty-five years has the measure received study and had extensive clinical verification as to its value. The pioneers in this field have been European surgeons, notably Sicard, of Paris, and Nobl, of Vienna. It is only within the last few years that the larger and well-known American clinics have accepted the injection of varicose veins as a sound therapeutic measure.

Histology of Veins.—The normal vein wall presents a wide variation in structure, depending upon the site from which the section is taken. The inner lining of the saphenous vein wall, or intima, consists of endothelium. The chief variation is seen in the two outer coats, the media and adventitia. Lying just peripheral to the intima is a thin layer of connective tissue which contains a few elastic fibres. The media, or middle coat, is much thicker than the intima and consists largely of circularly arranged smooth muscle fibres and connective tissue. The adventitia, or outer coat, consists chiefly of connective tissue in which are seen fibres of elastic tissue circularly arranged. Smooth muscle has been described as being present in this part of the vein wall.

A section of vein taken from the lower tibial region presents a different picture from that described above. The smooth muscle in the media is arranged longitudinally instead of circularly and there is none present in the adventitia.

Varicose veins[1, 2, 3] present a picture of wide variation in the degree of degeneration of the vein wall. Some investigators are of the opinion that there is hypertrophy, and others that there is atrophy of the wall. The elastic fibres appear to be atrophied with a relative increase in the amount of connective tissue. The smooth muscle is atrophied in the more advanced cases.

In those cases of long duration the vein wall has the appearance of a thin membrane with the smooth muscle having the appearance of connective tissue. The intima in some cases is thickened, in others unaltered.

There is much confusion as to how œdema and ulceration of the tissues take place. Simple œdema is hardly sufficient reason for the presence of ulcer as there are many conditions accompanied by œdema which never produce ulcers. Consequently, another reason, perhaps associated with œdema, must be sought for. Hydrostatic pressure is not an underlying factor as studies have shown that the pressure in varicose and normal veins does not differ.[4] It seems most probable that ulceration results from inadequate nutrition of the tissues.

Where possible, one member of the body usually adapts itself to the increased work demanded of it when another member is devitalized or removed. It is logical, therefore, to assume that the communicating veins between the deep and superficial saphenous systems would enlarge sufficiently to carry the blood from the leg. This evidently does not take place. It then can be further stated that there is some interference with the return flow of these veins, assuming that they are patent, which has been shown to be the case in all uncomplicated cases of varicose veins.[5] What is this interference? It can only be the blood entering the communicating veins from some other source; and this source can only be the saphenous receiving blood from the common femoral vein and returning it to the deep system by way of the communicating veins, thereby interfering with the compensatory drainage of the leg. Recent studies tend to show that the blood volume in the leg with varicose veins is greater than that in the normal leg.[6] This theory is further substantiated by the rapid reduction of œdema and the subsequent healing of ulcers following the obliteration of varicose veins and the reëstablishment of adequate nutrition to the tissues.

Etiology.—The underlying cause of varicose veins still remains obscure. Certain contributing factors are well known and will be but briefly mentioned. The causes can be classified as direct and indirect. The direct causes are any condition or conditions which interfere or tend to interfere with the return flow of blood in the veins, *i.e.*, the wearing of garters around the leg, long periods of standing on the feet, pregnancy and tumors of the pelvis in women, and transient periods of increased intra-abdominal pressure as in coughing, sneezing, *etc.* In some cases, there may be a low-grade inflammatory process resulting in the weakening of the valves and walls of the veins, but one or more of these conditions are operating in the majority of people more or less constantly and all do not develop varicose veins. It is therefore logical to assume an underlying factor upon which the direct causes are superimposed.

In this series of 354 cases, 56 per cent. of the patients stated that some member of the family had suffered or was suffering from varicose veins. Sixteen per cent. stated that some member of the family had "trouble with his legs" but they were not certain about the presence of varicose veins. One patient, observed over a period of many years, first developed varicocele

and now has varicose veins and, in the family, the mother and three sisters have varicose veins.

Bier and Lehmann propounded the theory of inherent tissue weakness in and about the vein wall and in the valves. Our observations are more in accord with this idea. Whether or not there is an accompanying faulty endocrine activity is a much discussed question, but the theory has its advocates.

Obstructive deep phlebitis resulting in compensatory dilatation of the external saphenous system has been seen by every physician and hardly enters into this discussion.

Selection of Cases.—It is very important to take good histories and examine patients presenting themselves for treatment. Those complaining of excruciating pains in the legs must be carefully studied for other conditions. Although varicose veins produce marked discomfort, it is not described as "excruciating." Endarteritis, thrombo-angiitis obliterans, and Raynaud's disease are occasionally seen and should be treated accordingly. Patients with varicose veins who also have arthritis, weak feet or sciatica should be treated for these conditions as well as for the veins, but they should be cautioned not to expect much relief from their discomfort until the other conditions have been improved. It is important to differentiate ulcers due to syphilis, diabetes or those resulting from trophic disturbances, and to treat them accordingly. Patients with compensatory varicosities following obstructive deep phlebitis should not be treated until all evidence of the acute process has subsided. We arbitrarily advise a period of eight months as a minimum time limit before treatment is begun. When treatment is started it is carried out with the utmost caution and all presenting veins are not obliterated. Invertase 60 per cent., the mildest sclerosing solution, is used because it is the least irritating, the least penetrating and is adequate in its sclerosing action. In these cases one must always be aware of the possibility of causing an acute exacerbation of the old phlebitis. These patients can be very definitely helped, but during treatment it should be constantly kept in mind that the presenting circulation is compensatory.

Choice of Solutions.—There is no one solution which satisfies all the requirements in every case. The patient as an individual should receive consideration, as well as the veins treated. The apprehensive and nervous patient will not tolerate the cramps accompanying the use of certain solutions. Furthermore, some veins sclerose more easily than others with exactly the same conditions operating. The size of the veins or their duration has little to do with their response to the solutions used. Consequently, one cannot limit himself to one solution and obtain consistently satisfactory results. Sodium salicylate in all concentrations is no longer used in this clinic. It is less efficacious when used routinely than some of the other solutions and the cramps which accompany its use destroy the morale of many patients. Occasionally, it is highly toxic and if any is injected into the

perivenous tissues a slough results which heals very slowly. Sodium chloride is not used for the same reasons.

We find that 5 per cent. quinine and urea hydrochloride when used routinely yields the most satisfactory results. Its chief disadvantage is that only small amounts can be used at a time: 1.5 cubic centimetres usually, and occasionally as much as four cubic centimetres. It is very toxic to many patients and this must be ascertained before it is used. Uncommonly a sloughing ulcer will develop if any of the solution is injected outside the vein wall. A chemical phlebitis occurs following its use more frequently than when other solutions are used. The condition, when it occurs, is temporary and is treated with rest and cold boric acid compresses. There is usually no elevation in temperature.

A 50 per cent. dextrose-30 per cent. sodium chloride combination solution is best for the large veins because as much as fifteen cubic centimetres at a time may be used without any general effects to the patient. It does, however, produce a rather severe cramp which lasts two or three minutes. Invertase 60 per cent. is the solution of choice for the small superficial type of vein and for those where there is some difficulty in entering the lumen. If any of this solution should be injected outside the vein wall, it will result in no slough.

Technic.—The technic is very simple and requires no elaborate armamentarium. Certain details, however, must be meticulously observed to avoid complications. A tourniquet should be placed above the site of injection when it is made in the thigh because of the close proximity of the opening of the saphenous into the common femoral vein. When injection is made below the knee a tourniquet is unnecessary. The semi-sitting position is the position of choice for the patient. A 25-gauge needle with a very short bevel is the most satisfactory to use. After the vein is entered, which is indicated by a *free* flow of blood into the syringe, it is emptied as completely as possible by a pumping action of the free hand before injection is begun. This serves to lessen the dilution of the solution used, thereby permitting more effective action on the vein wall. While the injection is taking place, pressure is exerted above and below the site in order to localize the solution. This can be done with the thumb and forefinger of the opposite hand. This can also be accomplished by means of several different types of metal rings which have been invented for this purpose. They are placed over about two inches of vein and held firmly by straps around the leg. Others have projections upon which pressure can be exerted. After the injection is completed pressure is exerted directly over the site by means of a cotton or gauze pledget. The needle is then withdrawn and the pledget is held in place for about twenty-four hours by means of one-inch adhesive strips. Injections are usually begun in the lowest part of the leg, gradually working upward. Two injections a week can be given. Strict asepsis is always observed. When œdema is pronounced or when there is an accompanying complication of ulcer, the use of an elastic bandage is advisable.

The technic, although described before with slight variations, is reiterated here to emphasize the importance of detail in this treatment. Sloughing ulcers are signs of lack of care and carelessness in inattention to detail.

The Pathological Process Which Follows the Injection of Sclerosing Solutions.—The process has been fully studied by many investigators and it is the knowledge of their results which has been responsible for the confidence extant in the efficacy of this measure.

The constriction of the vein results in the slowing of the blood-stream and the presence of a foreign solution inimical to the blood elements results
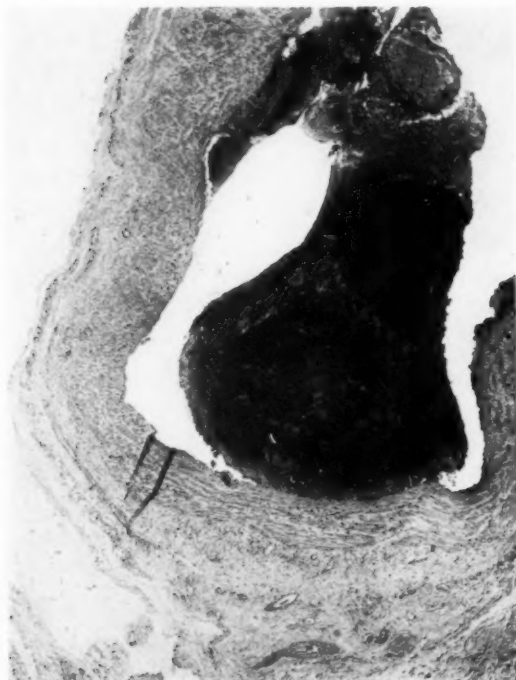
FIG. 1.   FIG. 2.

FIG. 1.—Microscopical picture of a vein three months after injection with five cubic centimetres of 30 per cent. sodium salicylate solution. No reaction in the vein wall and no organization taking place in the clot.
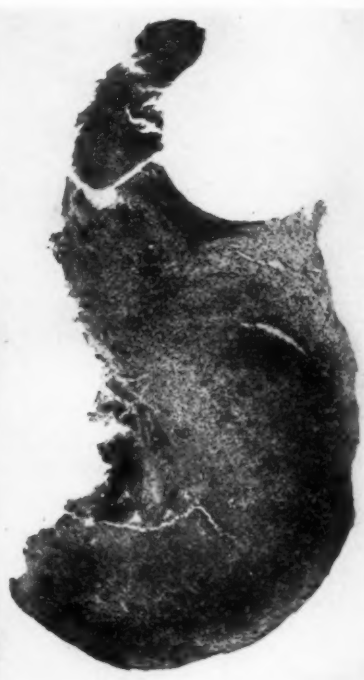
FIG. 2.—A section of vein wall removed one month after the injection of two cubic centimetres of 5 per cent quinine and urea hydrochloride showing the reaction which has taken place, with the growth of fibroblasts.

in clotting. The action of the solution causes a hæmorrhagic appearance of the intima followed in most cases by sloughing. Following this there is cellular infiltration of the vein wall. This varies, depending upon the degree of reaction taking place in the media and adventitia. With the beginning of the organization process fibroblasts grow from the vein wall into the clot. There is gradual formation of fibrous tissue and the clot is absorbed and the lumen obliterated. The result, after a few weeks, is a fibrous cord replacing the varicose vein. This requires sometimes several months before it entirely disappears.

Fig. 3A.

Fig. 3B.

Fig. 3A.—At the beginning of treatment patient has, in addition to other large veins, an area of phlebectasis ("punchy" veins) below the left knee.
Fig. 3B.—The same patient at the end of six months. The "punchy" veins have entirely disappeared. One injection of two cubic centimetres of 5 per cent. quinine and urea hydrochloride on two separate days accomplished this result. Now, two and one-half years later, no recurrences.

There are times when, apparently, no organization takes place. Fig. 1 illustrates this point. The lumen of the vein is filled with the clot attached to one side of the wall. There is very little destruction of the intima and no reaction in the media or adventitia with no organization taking place. Before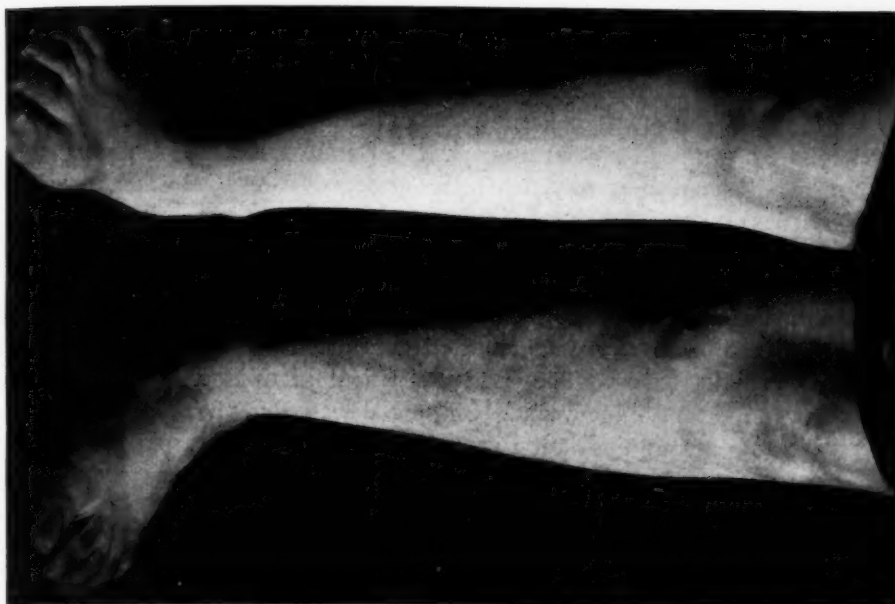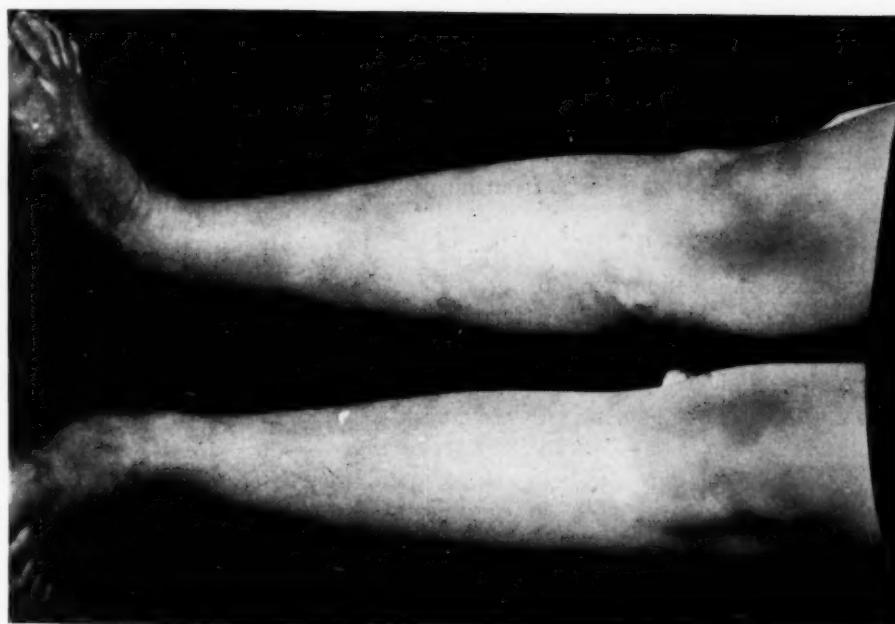 treatment the vein was one centimetre in diameter. It eventually disappeared and, after two years, shows no evidence of recurrence. Clinically, the results are excellent; theoretically, when this process follows injection, recurrences might be expected.

Contraindications to Treatment.—Any case can be treated excepting those patients having any evidence of active disease. When a fair measure of health has been restored to them treatment can be started or resumed. There is no age limit. A great amount of comfort can be given to the aged as well as to the young. The youngest patient in this series is eighteen and the oldest seventy-nine years. Chronic diseases as they appear in elderly people are no contraindication provided there is a fair margin of health left. Those patients with inflammatory conditions about the legs should not be treated until all signs have entirely disappeared.

Comment and Results.—Of the 354 cases treated by the writer, 127 discontinued treatment after improvement but before they were discharged as cured, 227 completed the treatment and were discharged as cured. Two of this latter number, or .8 + of 1 per cent., returned within six months with recurrences. Ten of the entire series had been operated upon previously for varicose veins. Two of the ten had been operated upon twice for the same condition. This group alone shows a recurrence of over 4 per cent. as compared to the above .8 per cent. following the injection treatment.

Some surgeons advocate ligation of the large saphenous vein below Poupart's ligament followed by injection of the remaining veins. We feel that there is no advantage in this procedure as our results have been entirely satisfactory when the saphenous has been injected at its high point in the thigh. Actually, there should be less danger from the sclerosing clot which forms after injection than from an ordinary clot which forms when a vein is ligated.

Areas of phlebectasis or the "bunchy" type of veins are successfully treated by injection and do not require excision. Fig. 2 illustrates one of these cases and the results after six months.

Complete coöperation of the patient is necessary to accomplish satisfactory results. When possible, two injections a week are advisable. The average number of injections per patient in this series was eleven and the greatest number given to one patient was fifty-one.

Ulcers.—Fifteen per cent. of our patients presented some form of ulcer. The majority have healed promptly following the obliteration of the large veins and the reëstablishment of adequate nutrition to the tissues. A drying bland ointment is used on the ulcer and an elastic bandage is snugly applied when œdema is pronounced. The ulcers surrounded by "brawny" indurated areas heal much more slowly because the varicose veins are difficult to get at

and it is only when this is accomplished that they will heal. A few are so obstinate that only rest in bed accomplishes the desired results.

CONCLUSIONS.—(1) A knowledge of the pathology is the basis for the confidence in the injection treatment of varicose veins and the high percentage of cures indicates its efficacy.

(2) No one solution satisfies all the requirements for the injection treatment, consequently several solutions must be at one's command in order to secure satisfactory results.

(3) Patients with any active disease should not be treated until the condition has entirely abated and several months have elapsed.

(4) Patients of all ages can be treated.

(5) Care and meticulous attention to detail will practically eliminate complications.

(6) The majority of ulcers heal rapidly following the obliteration of the varicose veins and the reëstablishment of adequate nutrition to the tissues.

(7) If but one solution is available, the most satisfactory is 5 per cent. urea hydrochloride and quinine.

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VARICO-PHLEBITIS AND THE INJECTION TREATMENT

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THE safety and effectiveness of the injection treatment of varicose veins has been adequately demonstrated. Nevertheless, annoying and even serious complications still occur in any large series of cases, and the method is attended by a definite if minute mortality. In the frequently quoted series gathered from the literature by McPheeters and Rice,[1] there were seven deaths in 53,000 cases. Laqua,[2] in a careful review, has collected three further reports, and unquestionably many other fatalities have escaped publication. Nevertheless it may be assumed that the figures above demonstrate the essential safety of the method.

In a critical analysis of the injection treatment, from the point of view of its safety, two questions must be asked:

1. Is the method as safe as any other now available? The evidence at hand suggests a strongly affirmative answer.

2. How does the mortality and morbidity of injection therapy compare with the incidence of death and disability resulting from the varicose vein syndrome itself?

The great contribution of injection treatment is the relief of disability which it has made possible. On this score, it needs no apologies.

The question of mortality is a more difficult one to answer. That deaths from embolism, hæmorrhage, and perhaps indirectly as the result of ulceration can and do occur, is not to be doubted. However, while information on the subject is meagre, such figures as are available suggest the extreme rarity of such fatal accidents. Thus Kolisko[3] points out that in Vienna from 1900 to 1907 there were fifty-nine deaths from embolism, only four of which were traceable to varicosities. Such evidence would seem to indicate that the mortality from varicose veins and their complications is almost negligible. That being true, no mortality rate from the injection treatment, no matter how small, can be accepted with equanimity. It is a question whether an occasional death can be regarded as a fair price for the relief of disability and suffering conferred.

The safety of chemical obliteration lies in the early firm adherence, the rapid organization, and the localization of the thrombus produced by injection. Its dangers are to be sought in deviations from this optimum response.

In any extensive series of injections, one is impressed by the wide variation in the local effects produced in various individuals, or with successive injections in the same patient. Roughly, these responses may be fitted into the following diagrammatic scheme. (Fig. 1.)

The injection may be without effect (1) or the lumen of the injected vein may be obliterated by the agglutination of its endothelial lining, (2) neither vein nor thrombus being palpable at the site of injection several days later. In the third case, a localized thrombus appears near the injection site, palpable as a firm longitudinal mass extending for several centimetres along the course of the vein. This reaction (3) constitutues the ideal response to a single injection made with the technic routinely employed in this clinic. The remaining reactions depicted in the scheme represent deviations from this optimum effect. Thus a single injection may produce a surprisingly extensive occlusion, involving a whole group or system of veins (4). Such a reaction has most frequently been observed in the greater saphenous system—where an injection in the lower thigh or even below the knee may result in a thrombosis which sweeps unimpeded along the straight, widening channel of the greater
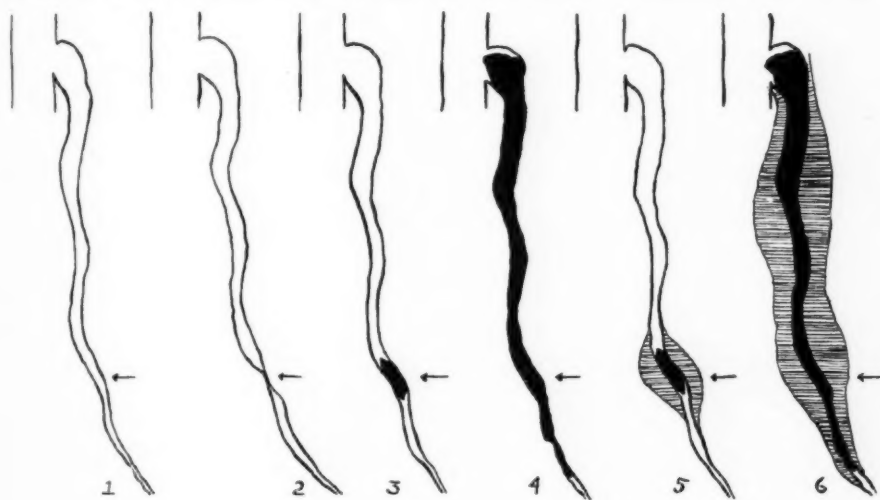
FIG. 1.

saphenous stem in the thigh, stopping only at the opening of this vessel into the femoral vein at the saphenous opening. While this reaction inspires a sense of distrust, it does not differ qualitatively from the preceding type (3) and is not greatly feared. The thrombosis is in all probability a "chemical" one, and the dilution of the injection medium together with the volume and velocity of the venous flow in the femóral vein are safeguards against its further propagation into the great vessels above. The remaining two reactions depicted differ qualitatively from those thus far described. Reaction (5) represents an occlusion restricted to a relatively small extent of the injected vein, but in addition there appears within a short time after injection a perivenous reaction, accompanying the vein for the extent of the occlusion, varying from a slight induration, somewhat reddened and tender, to a massive, tender, painful red swelling, following the course of the obliterated vein. Such a reaction may also become extensive, involving, for example, the entire

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saphenous system, extending along the saphenous stem, to stop menacingly at the saphenous opening (6). It is this type of response which carries with it the greatest danger of embolism and of an ascent to the major deep veins above, and is consequently viewed with the greatest concern.

An analysis of the tables here presented, compiled chiefly from Mc-Pheeter's[1] and Laqua's[2] reports will demonstrate the genuineness of these

TABLE I

Ascending Thrombosis; Recovery

Author	Solution	Ascending thrombosis	Embolism	Deep vein thrombosis	Death	Remarks
Hirsch......	Varicosmon	+	o	+	o	Common iliac thrombosis œdema of both legs
Löhr.......	20 per cent. NaCl	+	o	+	o	Diagnosis of Vena Cava Thrombosis
Redner.....	—	+	+	+	o	Diagnosis of bilateral femoral thrombosis, repeated embolism
Reimann....	Glucose 50 per cent.	+	+	+	o	Severe thrombophlebitis, repeated embolism

TABLE II

Embolism, death, no ascending phlebitis noted

| Olson....... | NaCl and Calorose | o | + | o | + | |
| McPheeters. | NaCl 25 per cent. | o | + | o | + | |

dangers. In Table I are listed four cases of extension to the major veins which terminated favorably. The eight fatal cases included in Tables II and III are only those in which death followed directly as a result of injection. In two of these (Table II) fatal embolism occurred in the presence of a clinically normal local reaction to injection. In four of the remaining cases,

TABLE III

Ascending phlebitis, embolism, death

Author	Solution	Ascending thrombosis	Embolism	Deep vein thrombosis	Death	Remarks
Hohlbaum..	Pregl's Solution	+	+	o	+	
Kausch.....	Pregl's Solution	?	+	?	+	Full details not available
Kühnau....	Calorose	+	+	o	+	
Lomholt....	NaCl 20 per cent.	+	+	o	+	
McPheeters.	NaCl 20 per cent.	+	+	+	+	"Entire leg swollen"
Levai.......	?	+	+	?	+	Septic thrombophlebitis. Quoted by Vigyazo

death followed an ascending thrombosis with embolism. In the fifth case, death occurred from a septic phlebitis, while information on the sixth is incomplete. Thus in the total of seven cases (Tables II and III) in which death was directly attributable to injection, for which adequate data are available, four were the result of ascending progressive thrombophlebitis and

embolism; two, of embolism alone, without an obviously abnormal local reaction; and one, of a septic thrombophlebitis.

The last two types of reaction (Figs. 1, 5 and 6) have received considerable attention in the literature. Meisen[4] (1927) spoke of the occlusion accompanied by a vigorous perivenous reaction as a "chemical phlebitis," and this conception has been accepted by McPheeters,[1] Cattel[5] and others. Cattel[5] has called the extensive thrombosis with perivenitis (Figs. 1-6) an ascending chemical phlebitis. McPheeters[1] on the other hand feels that all extensions from the local reaction which itself may be due "to a certain amount of fluid passing through the thin vein wall by osmosis," must be regarded as infectious in origin, the results of the lighting up of a latent phlebitis. This view is shared by de Takats.[7]

The writer agrees that some of the local reactions with periphlebitis are indeed chemical in origin. Nevertheless, there is reason to believe that here, too, the lesion is an infectious one in a large percentage of cases. Indeed, the line between so-called chemical phlebitis and a true infectious phlebitis following injection may be exceedingly difficult to draw. This point is illustrated by the following case:

Case I.—A woman of forty-six, in excellent general health presented herself at the Northwestern University clinic on July 23, 1930, with very large varicosities involving the entire extent of both greater saphenous systems. There was no history to suggest either a superficial or deep vein phlebitis. Because of the size and upward extent of the varices, a bilateral high ligation of both saphenous trunks was decided upon. Through a misunderstanding, while the patient was awaiting ligation, three injections of glucose and saline were made into the varices below the left knee. On August 22, 1930, the patient presented herself for ligation. Because of a red tender swelling which extended for about 7 centimetres along the course of a recently injected vein on the left, no ligation was done on this side. The usual ligation was done on the right. A week later she returned. The ligation wound was clean. A firm thrombus occupied the short proximal stump of the vein, but the distal segment was collapsed and empty. On the left side, however, a firm, reddened, tender mass had appeared in the course of the greater saphenous trunk in the thigh. A distance of at least 10 centimetres intervened between this swelling and the mass below the knee previously noted. While somewhat more extensive, the lesion in the thigh was scarcely to be differentiated in its general clinical characteristics from that below the knee. The patient's temperature was 99° F. Two weeks later an injection into the saphenous trunk on the right, several inches below the point of ligation, resulted in a lesion clinically identical with that which had appeared previously, first below and subsequently above the left knee.

Although the lesion appearing in the left thigh more than a week following injection could scarcely be interpreted as a "chemical phlebitis," it was clinically in all essentials similar to the reaction which had previously followed injection on the left side, and subsequently developed about an injection site below the point of ligation in the right saphenous trunk. To what may the marked reactions in this case have been due? We are becoming increasingly convinced of the essentially infectious nature of such lesions and our interest has consequently been aroused in the possibility of the existence of latent or "resting" infection in the walls of the affected varices. During

recent months, Dr. A. I. Kendall[6] and the writer have succeeded in accumulating suggestive bacteriologic evidence in support of such a possibility. Furthermore, evidence of a clinical nature in favor of such a view is abundant. Thus spontaneous thrombophlebitic lesions, clinically similar in all respects to those just described, are seen with remarkable frequency in this clinic. (Fig. 2.) More interesting still are the reactions occurring as the result of mechanical factors. De Takats has seen a marked involvement of this type

Fig. 2.—Large phlebitic patch occurring spontaneously in the varicosed trunk of the left greater saphenous vein at the level of the knee-joint.

follow the simple aseptic puncture of a varicose vein. An even more striking demonstration is furnished by the massive thrombosis with periphlebitis which frequently occurs along the saphenous trunk distal to the point of a high ligation. This phenomenon, and other interesting evidences of the rôle of resting infection, are illustrated by the following two cases:

CASE II.—A woman of thirty-four came to the Northwestern Dispensary on November 18, 1930, for the relief of varicosities of sixteen years' standing. Examination revealed a very marked involvement of the right saphenous system extending to the saphenous opening, and a less marked involvement on the left, the moderately enlarged

trunk of the saphenous being palpable on this side to the mid-thigh. A preliminary ligation was decided upon for the right side; injections for the left. On November 21, a high ligation of the right saphenous stem about two inches below its femoral opening was performed under local anæsthesia. On examination on November 25, 1930, the wound was perfectly clean. A firm, moderately tender, dull red induration had appeared the previous day on the medial aspect of the lower third of the leg just above the internal malleolus. This extended for about 10 centimetres along the course of the greater saphenous trunk which was thrombosed for a corresponding extent. The temperature was 99° F. On November 28, 1930, the process had extended almost to the level of the knee. On December 4, 1930, however, the process began to extend to the thigh, so that on December 5, 1930, there was a thrombophlebitis terminating about three inches below the site of ligation. There was no further extension, so that by December 19, 1930, the periphlebitis had almost subsided, the firmly thrombosed saphenous trunk being palpable as a firm cord running from the ankle to the point of ligation.

Here again the evidence points strongly to the existence of latent or resting infection, swept into activity by the trauma and stasis resulting from a simple ligation at some distance from the point of first appearance of the inflammatory process. It is to be emphasized that the post-ligation phlebitis presents all of those gross clinical characteristics described for the lesion appearing spontaneously and following injection or simple puncture.

CASE III.—A fifty-six-year-old woman in good general health was first seen in the Northwestern University clinic on November 18, 1930. At the age of eight she had "typhoid fever." No details concerning this illness were available. As far as she knew there had been no trouble with either leg at that time. Four years previous to entrance she developed a painful swelling of the entire right leg and thigh, as a result of which she was bed-ridden for several weeks. There had been no return of the swelling. Two weeks ago a small tender patch appeared on the right leg—below the knee—and this persisted. On examination there was an ovoid thrombophlebitic patch involving a clump of varicosities below the right knee on the medial aspect of the right calf. Other varicosities were scattered over the calf. The deep veins, by the usual criteria, were patent. With a series of Unna's paste boots, the patch on the right subsided and on January 13, 1931, 5 cubic centimetres of a glucose saline solution were injected into a varicosity below the knee on the opposite (left) side. She was seen at her home several days later. The entire left saphenous trunk was thrombosed, with a tender, moderately red periphlebitic reaction. A firm, tender mass occupied the proximal end of the vein, high in the groin, at the saphenous opening. After several days of rest and elevation she was seen again. Her temperature was normal. A massive œdema had developed, however, involving the entire leg and thigh; and the greater saphenous trunk was still present as a tender, swollen induration. Three months later, the entire left greater saphenous stem remained firmly thrombosed, and there was a gradually decreasing œdema of the leg and thigh.

It is now felt that the history of a deep phlebitis four years previously on the right side, together with the presence of a recent superficial phlebitic patch, should have served as a warning of the possibility of trouble from any therapeutic manipulation which might be undertaken on the left in this case. That a phlebitic tendency may be bilateral is also demonstrated by Case I above.

It has been suggested above that the most important direct dangers of injection treatment arise in association with the thrombophlebitic reactions which may follow injection. The evidence here presented indicates the probable importance of resting infection as the background for such reactions.

The problem of preventing some of the most serious complications of this form of treatment is therefore intimately concerned with the problem of resting infection. The precautions which are to be taken to avoid the lighting up of such infection in the vein walls may be briefly indicated here.

In the first place, the importance of avoiding injection in the presence of definite patches of superficial phlebitis must again be stressed. Ample time—we are still often waiting several months—must be allowed for the subsidence of such processes. In the absence of frank lesions, the greatest caution must be observed where there has been a history of post-operative, post-puerperal, or post-infectious (typhoid, pneumonia) deep vein occlusion. Here the problem may present material difficulties. What specific means are available for the detection of resting infection in such cases? In other fields of surgery, fairly adequate methods for the detection of resting infection have been developed (Fründ,[8] Kuntzen,[9] Payr[10]). The subject has been reviewed in detail by Payr in whose clinic extensive and systematic examinations for latent infection have been made before undertaking plastic operation on bones which have previously been the seat of infection. These examinations include studies of surface temperature, the leucocyte count in the neighborhood of the tissues in question; the sedimentation time, agglutination tests, and careful blood counts; and finally and most important, in attempts to elicit a local inflammatory response by various forms of mechanical, thermal, and chemical excitation, and by irradiation. Such tests, particularly the observation of the effects of mechanical stimulation (massage, tapping with a wooden mallet, etc.) and of exposure to X-rays have proven of very material value in the particular application mentioned. In the Northwestern clinic, investigations have thus far been restricted to mechanical excitation (massage or puncture), chemical stimulation (preliminary injections of small amounts of the medium to be used) and thermal excitation (exposure to diathermy). The latter method has been found of value by de Takats,[11] although Payr was not impressed by its usefulness in the field of plastic bone surgery. Further trials, particularly with X-ray irradiation, will be made.

The fate of the injection method will depend on a continuation of our present belief in its effectiveness and safety. Its effectiveness will be guaranteed by the proper choice of cases and liberal and appropriate combination with other therapeutic measures—matters which are not within the scope of this paper. Its safety will depend, at least in part, upon a clearer appreciation of the significance of resting infection and varico-phlebitis.

SUMMARY

1. Clinical evidence pointing to the existence of resting infection in the walls of varicose veins is presented.

2. The dangers of the injection treatment of varicose veins arise in part from the lighting up of such infection, with resulting ascending thrombophlebitis and embolism.

3. Evidence of the presence of latent infection in the veins of one extremity should call attention to the likelihood of stirring up such infection in the opposite extremity.

4. The development of adequate methods of detecting latent infection will aid in eliminating an important source of danger associated with injection therapy.

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THE RELATION OF CHRONIC VARICOSE ULCER TO EPITHELIOMA

BASED ON RECORDS OF OVER 1,000 CHRONIC LEG ULCERS

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FROM THE KINGS COUNTY HOSPITAL

Cutaneous carcinoma of the lower extremities is of very rare occurrence. Broders,[1,2] in a series of 2,000 cases of general epithelioma, at The Mayo Clinic, recorded only twelve instances where the lesion was located on the lower extremities, and, furthermore, stated that over 96 per cent. of his cases occurred above the level of the clavicle. De Asis,[3] in a study of all cases of epithelioma occurring in two hospitals in St. Louis, found that out of a total of 6,766 only eighteen were located on the lower extremities. Simpson and Anderson,[6] in a series of 500 epitheliomata, found a total of only twenty-four cases for both upper and lower extremities.

In a study of the same subject at the Kings County Hospital, Brooklyn, on the surgical service of Dr. Joseph Tenopyr, fourteen cases of epithelioma of the lower extremities were found for the period 1921-1931, inclusive. (Table I.) The records for the entire hospital showed the presence of five more cases, making a total of nineteen cases. During the same period over 1,000 chronic leg ulcers were admitted. Many of the malignant cases came in with a diagnosis of chronic varicose, or trophic, ulcer. A biopsy in each suspected case eventually revealed the true condition.

TABLE I
Epitheliomata of the Lower Extremities

No.	Name	Age	Sex	Duration of Lesion in Years	Wassermann	Pathological Type	Treatment	Result	Site of Lesion
1	P. M.	54	M.	20	neg.	squamous-cell	amputation	died	chronic varicose ulcer
2	J. H.	62	M.	10	neg.	basal-cell	amputation	recovered	chronic varicose ulcer
3	M. F.	52	M.	15	neg.	basal-cell	palliative	died	chronic varicose ulcer
4	M. C.	60	M.	?	neg.	not stated		not improved	chronic varicose ulcer
5	P. B.	57	M.	15	neg.	squamous-cell	amputation	recovered	osteomyelitic wound
6	C. H.	60	M.	18	pos.	squamous-cell	amputation	recovered	scar of old burn 18 yrs.
7	E. G.	52	M.	11	neg.	no report	palliative	died	2 yrs. after compound fracture of leg
8	F. M.	55	M.	1½	neg.	squamous-cell	X-ray	improved	ulcer on heel
9	W. A.	50	M.	1½	neg.	basal-cell	X-ray	improved	ulcer on heel
10	C. C.	75	M.	40	neg.	squamous-cell	amputation	recovered	lesion on left ankle
11	A. C.	55	F.	¼	pos.	squamous-cell	palliative	died	right leg
12	A. S.	62	F.	1	neg.	squamous-cell	amputation	died	growth on left foot
13	A. B.	49	M.	3	neg.	squamous-cell	X-ray	improved	left thigh
14	A. W.	77	F.	1	neg.	squamous-cell	palliative	died	lesion on left foot

It was at first thought that a causal relationship existed between chronic varicose ulcer and epithelioma, but the results of the present study failed to substantiate this view, for only four of these cases gave a history of chronic

varicose ulcers of long duration. Two others gave a history of ulcers of a few years' duration which may well have been malignant from the beginning, it being well known that rodent ulcers, and even squamous epitheliomata, may last for many years. Broders[2] states that the average duration for general epithelioma in his series varied from three months to forty-five years with an average of seven years. Sutton[4] states that the basal-cell types may last thirty years. It is obviously incorrect to conclude that because the lesion had hitherto been considered as a chronic infectious or varicose ulcer and

FIG. 1.

FIG. 2.

FIG. 1.—(Case I.) Lesion began as an ulcer of the heel and was treated as such without improvement until biopsy revealed it to be a basal-cell epithelioma.
FIG. 2.—(Case II.) Epithelioma arising on the site of a chronic varicose ulcer. Patient had ulcers of both legs. First biopsy was negative, but one year later a second revealed the presence of an epithelioma.

recent biopsy shows the presence of an epithelioma, that the benign chronic ulcer has undergone malignant changes. This difficulty is all the more great since White[7] and Weidman[8] have recently shown what they believe to be pseudo-epitheliomatous hyperplasia at the margins of cutaneous ulcers. This will be discussed more fully.

In this series, therefore, those cases where the onset of symptoms were of less than three years' duration were classed as primary malignancies. Those cases that gave a history of previous varicose veins with varicose

ulcers, successful skin grafts, osteomyelitic wounds, compound fractures, or burns, were considered as non-malignant chronic ulcers up to the time when the records showed that sudden proliferation, erosion, sloughing, and cachexia occurred, or biopsy revealed the diagnosis. Of the fourteen cases which are the subject of the present report, five gave a straight history of primary skin carcinoma, and two more a history of ulcers of less than two years' duration which were probably malignant from the start. The remaining seven gave a history of a previous benign lesion as follows: Varicose ulcers, four; osteomyelitic wounds, one; compound fracture, one; ulcer in scar of old burn, one. In two cases biopsies taken at intervals of four months and one year revealed a change from the benign to the malignant. However, too much reliance was not placed on these findings as the original biopsy may have been taken from a non-malignant portion of the wound which had resulted from secondary infection and necrosis of normal tissue. The following case illustrates this point very well:

CASE I.—C. C., a white male, aged seventy-five years, complained of an ulcer on the internal aspect of the left ankle. Forty years ago there appeared a small scab-like formation in the same region. It grew larger slowly and itched severely. He had it removed by electrosurgery. Some time after this the lesion recurred, became "mushroom-like," and a series of wart-like growths spread up the leg following the lymphatics. Various diagnoses were made at this time. On admission to the Kings County Hospital the left leg showed a large ulcerating lesion of the ankle with indurated, heaped-up borders. A biopsy taken at this time revealed: ". . . areas of ulceration of the epidermis, small round-cell invasion with plasma cells especially around the coiled gland ducts, numerous colonies of Gram-positive cocci."

Four months later another biopsy was taken and this time the report was different: ". . . marked hypertrophy of the epidermis with considerable keratosis. Situated in the derma and subcutis is a neoplasm composed of irregular islands and columns of squamous epithelia. Pearl formation is absent. Some of the squamous cells are markedly enlarged. The general architecture of the tumor would place it in Grade I. . . . Diagnosis.—Squamous-cell epithelioma."

This case was undoubtedly one of epithelioma from the very beginning despite the biopsy and was masked by the extensive secondary infection of the skin.

Recently White[7] and Weidman[8] described cases of ulcers in which biopsy reports were made of grades I, II, and III malignancy which healed under the treatment given for benign ulcers. Their cases, however, occurred chiefly in young persons under thirty-three years of age, their duration was in each case less than two years, and they were all of comparatively small size, five by one centimetres in diameter or less. In the present series, on the other hand, all the patients were in the cancer age, most of them in the fifth decade, and the lesions were either of long standing, having healed and broken down several times, or were so extensive as to involve the major portion of the extremity and erode bone. The smallest lesion was seven and a half centimetres long and the largest over thirty. It will be remembered that most of these patients were from the lower strata of the population and were very

neglectful of their personal hygiene. As the lesions were quite painless, hospitalization was greatly delayed.

Only three females were affected in this series as against eleven males, a ratio of almost 4:1. This is in accord with Broders'[1,2] series for general epithelioma of the body where the same ratio prevailed. In De Asis' series, males also predominated 2½:1. All of the cases occurring secondary to benign lesions were in males, the three female cases being all primary epitheliomata. Knox,[5] in a very careful study of the literature, collected a series of fifty-nine cases of epithelioma secondary to chronic varicose ulcers and about an equal number arising on scars of burns or fistulæ. In her series males and females were almost equally affected. But varicose veins and varicose ulcers are much more common in women than in men.[14] Apparently, then, chronic varicose ulcers seem to have little influence, if any at all, on the incidence of malignancy.

The scars of burns, on the other hand, played a larger part in the incidence of epithelioma in Broders' series, for one-fifth of his cases had such a base of origin. Epithelioma arises in lupus scars frequently,[10] 2 per cent. according to Zweifel-Payr. The same authors state that it is almost never seen arising in the active stage of the tuberculous lesion. The incidence of epithelioma in chronic varicose ulcers in the present series was 4 in 1,000, or 0.4 per cent. This is indeed a low figure if we believe that chronic irritation to which a leg ulcer is constantly being subjected has an influence on malignancy, especially with the use of ointments and irritants to stimulate granulation over periods of months and years. These figures compare favorably with a similar experience of Gottheil,[12] who saw only three cases of malignancy arising in chronic varicose ulcers at the Metropolitan Hospital, New York. The collected cases of De Asis showed that only one of the eighteen epitheliomata arose in connection with a varicose ulcer. Volkmann,[13] Nobl,[9] Grosser,[11] Gant,[16] and DaCosta[17] had similar experiences. One cannot fail to be impressed, therefore, with the fact that the chronic varicose ulcers, in spite of their duration of ten or twenty years, and in spite of the fact that they occur in individuals living in the decades when epithelioma is most common, play only a very minor rôle, if any, in the causation of cancer.

The part played by syphilis has been stressed by some writers. In this series only two cases gave a history of a positive Wassermann.

SUMMARY

(1) Nineteen cases of epithelioma of the lower extremities occurred at the Kings County Hospital for the period 1921-1931, inclusive.

(2) Over 1,000 chronic leg ulcers were admitted during the same period.

(3) Only four cases of epithelioma were found among these arising on the sites of such ulcers that had been present for ten to twenty years.

(4) The weight of evidence, therefore, is strongly against the common belief that chronic ulceration over prolonged periods plays an important rôle in the causation of cancer.

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THE PROBLEM OF DELAYED UNION AND UNUNITED FRACTURE

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In treating the police and firemen we deal with a large number of men who perform hard, manual work and who are very liable to severe injury. We have a large number of these two surgical conditions to treat. The memory of our surgical failures as well as those of other surgeons is constantly with us. The surgeon who does not make mistakes makes no great progress. The best of men and the most earnest workers will make enough mistakes to make them humble.

The object of this address will be to emphasize some of the etiological factors of delayed union and non-union, and to suggest certain methods of reducing the liability of these complications. It is realized that delayed union, non-union and pseudo-arthrosis may be three separate entities, often with varied etiological factors and requiring different treatment, but for the purpose of this paper they will be considered together.

Wilcox[1] has aptly said: "This is an age of acceleration, mass production, high-speed machinery, automotive and ærial activity." This ever-increasing demand for greater speed and more thrills connected with the desire for more hazardous sports is largely accountable for the increasing number of physical injuries, especially fractures. One often wonders when this craze for thrills and speed will end.

In order to emphasize some of the points with a view of appreciating exactly the incidence of ununited fracture, 11,683 fracture cases treated at the Philadelphia General and the Jefferson hospitals from 1921 to 1931 have been reviewed. There were 101 cases treated for non-union.

The occurrence of delayed union, according to Von Bruns, is one-half of 1 per cent.; according to Scudder, 2 to 3 per cent.; according to Heygroves, 4 to 5 per cent.

As the number of fractures is ever increasing, so the complications of fractures, including non-union, will increase. With the advent of motorized fire apparatus, motor-cycles, sidecars and bandit chasers our problem of dealing with fractures is a serious one. Severe accidents at fires are not as frequent as heretofore. This reduction is due to saner methods of fire prevention, fewer fire hazards and better construction of buildings. Transportation to and from fires is far more hazardous because of congested traffic.

The problem of fracture heretofore was one which concerned principally the surgeons of our city hospitals. There were two reasons for this: First, the majority of fractures occurred within the city limits; secondly, the more

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* Annual Address before the Philadelphia Academy of Surgery for 1931.

severe fractures which occurred in the rural districts were usually transported to a city hospital. At the present time the frequency of automobile accidents on the crowded public highways renders it imperative that the physician in each hamlet, village or even at crossroads be prepared to render proper treatment for fractures. These cases are now transported to a nearby hospital rather than to a city hospital, so that the surgeons of these suburban hospitals are now called upon to treat the more serious cases occurring in the suburbs.

Regarding the treatment of fractures by the general practitioner, Wilson and Cochran[2] remind us that, notwithstanding the lack of suitable facilities, the same standards of treatment and the same qualities of results as obtained in the best hospitals are demanded by both the public and the courts.

Modern text-books on surgery divide the etiology of delayed and non-union into two main classifications—constitutional causes and local causes. These statements, like many others in our text-books, have been repeated from one edition to another without contradiction.

Constitutional factors have but little, if anything, to do with the union of fractures. The diseases usually enumerated as causative factors of delayed and non-union are syphilis, tuberculosis, diabetes and blood dyscrasias. In our series of 101 cases, the Wassermann was positive in six cases, negative in ninety-one, not taken in four; the blood chemistry was normal in eighty-nine, abnormal in six, five of which showed a hyperglycæmia and one a hypoglycæmia, not being taken in six; pulmonary tuberculosis was noted in two cases.

Campbell[3] states we do have constitutional ailments which prevent union but that they are so rare that, excepting in those fractures which are infected, union will occur in 95 per cent. of the cases, and that non-union of fracture is undoubtedly caused by local interference with the physiological or nature's attempt at producing union.

Newell[4] does not believe that systemic conditions have anything to do with union or non-union. He considers the condition an entirely local one.

Wilson,[5] from his studies, agrees with Henderson[6] that local causes are far more significant in the development of non-union of fracture than general or systemic causes, but states that the chemical analysis of the blood to determine the calcium and sulphur content is valuable in a small number of cases.

Henderson, in discussing this subject two years ago, stated than in The Mayo Clinic up to that time, so far as he knew, there had been only one case of non-union which could actually be ascribed to syphilis.

Culbertson[7] has found that in normally healing fractures the catabolism of calcium shows but little change. There is a marked loss of nitrogen, phosphorus and sulphur, the main excretory path for these catabolies being the kidney. He, further, found that metabolic analysis did not throw any light upon the problem of ununited fracture. A catabolic loss of sulphur, nitrogen and phosphorus may result from injury to tissues other than bone.

The majority of writers, as pointed out by Lacey,[8] do not believe that the calcium and phosphorus index can be used as a prognostic index of union or non-union.

Bohler[9] believes that such diseases as tuberculosis and lues, and even osteomalacia and rickets, only delay but do not prevent union. He adds that non-union after fractures of the shaft is chiefly found in powerful and healthy individuals and disproportionately

more common in men than in women. We found in our series seventy-three cases of ununited fracture in the male and twenty-eight in the female. One reason for the disproportionate frequency of non-union in men may be due to the fact that men are subjected to more severe injury, and, being more muscular, there results greater shortening and greater trauma in attempts to reduce this shortening. Certainly rickets cannot be a cause of non-union as orthopædic surgeons deliberately fracture rachitic bones and non-union is practically unknown.

As quoted by Pat Fite,[10] there are some surgeons who believe that osteoblasts occur either from migration at the ends of bone or are formed from newly made connective tissue by metaplasia and that due to the activating enzymes produced in these cells calcification is brought about. Other workers at the Presbyterian Hospital in New York fairly recently have sought to show that from their experiments this is not the case, and, further, that the available source of calcium at the site of the fracture is due to tissue death and that an enzyme if formed is due to the death of this tissue and is probably affected in no way by the blood calcium.

Fite also notes the fact that non-union of the tibia occurs where there is poor lateral blood supply and also believes that in certain cases of fracture, as in the case of the neck of the femur or tarsal scaphoid, that union is affected by being bathed in synovial fluid. He believes that fractures bathed in synovial fluid are hampered to some extent in union because of slow and perhaps imperfect callus formation. Other surgeons deny this.

Bohler cites as the causes of non-union lack of reduction of fragments and interposition of soft parts, and emphasizes that the most common cause is insufficient and inadequate early treatment.

It is interesting in this connection to consider the thoughts of some of the earlier surgeons. Black,[11] writing in 1797, states that his era was "an age of investigation of fractures in which mankind was eager to attain even absolute perfection." He observes: "Although the science of surgery has reached a very high degree of perfection, yet there still exists considerable disagreement of sentiment on many points and perhaps none more than on which is the best mode of treating fractures." He adds that "falls, blows and bruises are said by many writers to be the common causes of fracture, but a little examination and reflection will be sufficient to prove that muscular action is a very principal agent in the production of fractures." Black further reflects that "in addition to this, we may observe that persons who are drunk or under the operation of any cause that produces relaxation of the muscular system, although they fall from a considerable height, seldom receive a broken bone." Even now, as then, a strange providence watches over those who violate the spirit of the eighteenth amendment.

Certainly fractures by muscular action are not as frequently complicated by non-union as fractures received by direct force. In our series of cases the primary injuries were:

Falls 47
Automobile accidents 24
Blows by external forces other than automobile accidents... 24
Crushing injuries 4
Gunshot wound 1
Stab wound 1

We found that non-union occurred in the first decade of life in three cases; in the second decade of life in eight cases; in the third decade of life in nineteen cases; in the fourth decade of life in nineteen cases; in the fifth decade of life in sixteen cases; in the sixth decade of life in sixteen cases; in

the seventh decade of life in eleven cases; in the eighth decade of life in seven cases; in the ninth decade of life in two cases. Of those occurring in the first decade, one was in a child three and one-half years old who was struck by an automobile and sustained a fracture of the left femur. The child was admitted to the hospital two months after the injury with non-union of the fracture. The second case was a child six years old with a fracture of the left humerus and non-union for two years and eight months. The third case was that of a child ten years of age with a fracture of the right femur, non-union duration of three months. These are unusual, as union occurs far more readily in the young than in the old. In this connection it is interesting to note that Gross reported firm union in a fracture of the humerus occurring in a patient whose age was one hundred years.

Local causes as etiological factors in delayed and non-union are far more important than constitutional factors. The most frequent of the local causes are: Lack of proper apposition or approximation of fragments; interposition of foreign tissue; injury to the blood supply; presence of foreign bodies in fracture zone; infection; and lack of proper fixation.

The question of nerve injury as an etiological factor is doubtful. There was but one case of our series which was associated with a nerve injury, that of a child thirteen years old, who sustained a fracture of the left humerus associated with musculospiral palsy. The case was admitted to the hospital eight months after the accident with non-union and wrist drop, but this does not necessarily mean that the musculospiral palsy was a factor in the non-union.

Injury to the blood supply is a well-recognized cause of non-union.

Cox[12] has emphasized the necessity of allowing for free circulation through veins and lymphatics as well as through arteries as through the medium of the veins and lymphatics the old structure is torn down and absorbed, thus permitting the growth of new vessels to form and the establishment of anastomosis so essential to bone repair. If resistance to expansion (swelling) occurs, its effect will be to diminish or occlude the veins, lymphatics and arteries, thus preventing an adequate supply of blood from reaching the interior of the callus. It is of great importance to prevent hæmorrhage, swelling and inflammatory reaction, especially during the early days of a fracture.

Impairment of the blood supply as an etiological factor in non-union was emphasized by Lacey in his excellent paper read before this Academy in 1929.

Bankhart[13] believes that the one common cause for non-union is the absence of hæmorrhage from between and around the fracture surfaces. He states that bones bleed when they are broken and usually there is considerable hæmorrhage between and around fracture surfaces. Extravasated blood, acting as a stimulus, produces the first step in the repair of the fracture. When for any reason sufficient hæmorrhage does not occur at the site of fracture, the natural stimulus for repair is lacking. He states that this is distinctly common in the case of fracture of the neck of the femur in an elderly person, not, as usually stated, on account of malnutrition of the fragments but simply on account of the absence of hæmorrhage, for these fractures are practically dry. He does not think imperfect immobilization is a causative factor, because, as he quotes: "Fractures of the ribs and other bones unite readily in spite of constant movement." He believes that systemic diseases are often causative in non-union because they are associated with arterial changes and, therefore, the bleeding around the ends of the fractured bone is very slight. For

delayed union he advocates the injection of autogenous blood around the site of the fracture. Bier has also used this method. Bier has also advocated the use of hyperæmia for delayed union. Diathermy and the use of certain therapeutic lights may be used to increase vascularity.

In this connection, it is interesting to note that it has been recognized for many years that irritation between the fragments will often stimulate osteogenesis. Celsus[14] used acupuncture and introduced bristles between the fragments to stimulate union. The insertion of ivory tacks and the injection of bone-marrow was used by Wyeth, in 1878. Thomas percussed the tissues over the ends of the fragments with a rubber hammer. Lannelongue and Menard[15] advocate the injection of a few drops, 1 to 10 solution, of zinc chloride between the fragments.

Proper allowance should always be made for the expansion of the soft parts. This has been further dwelled upon by Newell,[16] who contends that the most important consideration in the treatment of a fracture is to maintain a good blood supply to the broken bone and to allow for free anastomosing circulation with the blood-vessels coming from the soft parts to the bone. He further directs that there should be as little manipulation of the bone as possible so as not to disturb the periosteum.

Cowan[17] attributes the cause of non-union to local anatomical conditions resulting from laceration of the periosteum, usually flush with the fracture line and separation of the fragments.

Callus is formed from bone-marrow from the broken splinters of bone, periosteum from the muscles attached to the bone and from the hæmatoma which is mixed with the fat of the bone-marrow.

Bohler believes that too short and interrupted immobilization of fractured bones is the cause responsible for non-union. Extensive detachment of the periosteum produces a large subperiosteal callus. Bohler has shown that in transverse fractures of the lower third of the tibia and in the middle third of the radius there is produced only a very slow-growing callus. He believes that to obtain firm union in fracture of the tibia from ten to twenty weeks are necessary and for fracture of the radius from six to twelve weeks, believing that the cause of delayed union in these bones is based on the fact that the bone-marrow in these fractures is open only in a small area. He reiterates that the cause of delayed union in fractures of the tibia is due to the fact that the anterior and medial surfaces are not covered by muscles and the blood supply to this area is, therefore, poor. It can be shown by means of the X-ray that in fractures of the lower third of the tibia callus formation takes place only on the lateral and posterior surfaces, while upon the medial and anterior surfaces, not covered by muscle, bone formation is frequently very slow.

In speaking of the rôle of bone-marrow in union, I am reminded of the quotation of an English surgeon[18] who said to his students: "You may think, gentlemen, the shaft of a long bone is occupied by marrow, but do not believe it; the medullary cavity is filled with base, black ingratitude which flows out when the bone is broken."

By what means may we possibly minimize the occurrence of delayed and non-union? Groves[19] has aptly stated that the three main types of mistakes in the treatment of fracture are neglect, delay and error of judgment. Delay in the efficient primary treatment of fracture accounts for three-fourths of the failures, which are frequently due to sheer carelessness or procrastination. Far too often a patient is admitted to the ward, and

nothing is done until the next day, when a skiagram is taken and the fracture may not be seen by the surgeon for a day or two unless some grave symptom arises. Every compound fracture should receive the same immediate care as a fractured skull or acute abdomen and the full surgical team should set about the problem. Extensive examination should take place at once, with no more delay than in the case of a ruptured gastric ulcer.

For the proper treatment of fractures one must understand the mechanics of fracture. We cannot agree with the deduction of Russell, who states: The only one bone being fractured finds in gravity an ally and help in treatment is the humerus and for this reason fracture of the humerus should be the easiest of all fractures to treat. He also adds: "Gravity aided by a sling and bandage, with very little guidance from the surgeon, will do the rest." He speaks of the Balkan frame "with iron splints" as the crucifixion method of treatment.

The successful surgeon is one who is mechanically minded. It is realized that surgery is becoming more and more specialized. We have beds assigned to the neurological surgeons, thoracic surgeons, genito-urinary surgeons and other surgical specialties. In many of the larger hospitals fracture cases are now segregated. It is by no means advocated that the treatment of fracture should be considered as a specialty, but every hospital should have a fracture service. The surgeon who is not interested in the treatment of fractures should graciously refer these cases to the surgeon who is adapted for this work. This procedure should add to efficiency. The segregation of fracture cases facilitates the use of the necessary equipment and adds to the convenience of the surgeon.

There was once an old adage:[20] "It is not necessary to go to a fracture as you would to a fire." This statement is untrue. Every fracture should be considered as an emergency.

Wilcox[21] remarks that "until not long ago the arrangement and treatment of fractures have been left to internes or junior house officers. Medical students should be taught that a broken bone is something more than a mishap and the laity should be made to realize the importance of this subject. There should be provision for immediate X-ray examination, both night and day. Assisting staff, internes and nurses should be definitely instructed in the methods to be employed for the treatment of fractures."

Findlay[22] strongly advocates that internes assigned to ambulance service should receive special instructions as to the first-aid treatment of fractures and additional instruction should be given ambulance drivers in methods of assisting the interne. He concludes that:

(1) The internes appreciate having specific equipment and knowing definite methods for treating any particular fracture.

(2) Their work is carried out more accurately, quickly, and gently with this knowledge and equipment.

(3) When ambulance chauffeurs have been given specific instruction, they coöperate with and assist the internes.

(4) The patients are more comfortable.

(5) Shock is lessened or prevented.

(6) Our results in the treatment of fractures in general have been definitely improved since proper treatment has been instituted at the site of accident.

Bancroft[23] emphasizes that immediate replacements of fractures is imperative because "several hours after fracture the swelling due to hæmorrhage which infiltrates the muscle bundles is so excessive that replacement becomes difficult." Non-union may result from the fact that extremities often have to be suspended for several days in order to allow the

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swelling to subside before reduction can be attempted. He, too, emphasizes that allowance must be made for free and adequate circulation and that in cases where reduction is not attempted for several days the gelatinous consistency of the callus interferes with manual correction of overriding and to correct this deformity only long-continued traction may suffice.

Ashhurst[24] insists that reduction should be secured within a few hours of the injury "because if the surgeon postpones reduction he finds it increasingly difficult to secure because the reparative processes of nature will not await his convenience." He further emphasizes that delay and especially oft-repeated attempts at reduction not only do great injury to the soft parts, but are apt to hinder the progress of union with the result of delayed union or even non-union.

When the case is admitted to the hospital, before manipulation is attempted, X-ray studies should be made. The value of the biplane fluoroscopical screen cannot be over-emphasized. A single picture is of no value, excepting to diagnose the existence of a fracture, and it may fail to do even that. An X-ray of the entire bones should be made, with more than one plane taken. Some surgeons advocate taking an X-ray of the corresponding bone of the opposite extremity. The X-ray should be repeated after the fracture is reduced. Fractures should be reduced preferably by the findings of an X-ray and not by manipulation. We thoroughly disagree with Russell,[25] who writes that "X-rays are the indirect cause of much unnecessary operating on fractures," and that "X-rays can rarely demonstrate anything of importance which cannot be more easily demonstrated with a tape measure," but we do agree with him in his thought that the inspection of fracture films by patients may have serious psychological results because far too often the laity, and especially juries, lay too much stress upon a line of fracture *per se*.

To reduce a fracture muscular relaxation is imperative. This was recognized by the early surgeons, who obtained muscular relaxation either by means of alcoholic beverage, opium or blood-letting. Black states that "the reduction of a fracture is in general attended by little trouble since extension and counter-extension be all that in a majority of cases are requisite." Furthermore, that "unless laceration be great or the muscular system in such a state as to be easily thrown into convulsive action, the resistance given is seldom so powerful as to baffle the judicial efforts of two or three persons," but, he adds, "it has been not uncommon for us to see or hear of six or eight or as many men as can stand around the patient to use their utmost force to extend a limb, which force has sometimes even been so great as to tear the muscles to pieces while the unhappy sufferer must calmly submit to a fate fashioned by custom."

Black advocates the treatment of bleeding *ad delquim animi*, producing a suspension of muscular action; that is, bleeding just to the fainting point. This, he states, is often successful and by this practice one can get sufficient relaxation of muscles so that the force of two or three persons will be all that is necessary to reduce a fracture. This practice of bleeding to the fainting point was also popular because the patient felt no pain from extension of the limb and replacement of the fragments. Fainting, it was said, could be produced with safety and readiness in proportion to the size and velocity of the stream of blood. Should the vein be small and the bleeding slow it was often necessary to open an artery. The radial artery at the wrist was the one usually attacked. Black frequently practiced this procedure with a lancet and stopped the flow by compress and bandage.

Black was not enthusiastic about splints. One of his chief objections to the use of splints for fracture was for the reason "men in general have a greater or lesser degree of bandy-legs and by the use of splints following fractures the leg is made to deviate from its former shape and from that of the sound limb which would be the case if completely straight."

He mentions the case of a man who had been accustomed to drink ardent spirits freely and whose whole system was in an irritant state. This patient fell to the floor and received "a very oblique fracture" of the bones of the right leg. During the first attempt

to reduce these parts severe spasms occurred and continued four or five days. During this time the lancet was used freely to dispose of the spasms. This was effected by repeated bleeding, cathartics and a vegetable diet. From the day of the accident to the ninth day he lost 125 ounces of blood, which conquered the disposition to spasm.

Black remarks that there are "some unfortunate cases in which the ends of the bone do not unite. The inflammation subsides and the integrants resume their former appearance, but the bones remain separate." This, he says, is usually due to the consequence of some disease in the part which destroys the first bond of union. In some cases certain authors advised an incision be made down to the bone and the ends of it be sawed off. This surgical procedure was practiced first by White, of England, in 1760.

Black also mentions a mode of practice which has been successful in his hands and at least merits a trial; namely, to make the patient exercise his limb by weight-bearing so as to produce inflammation, thus causing an extravasation of coagulated lymph and the parts are united by a kind of granulation, but he spoils this modern thought of treatment by adding "if this is unsuccessful all that can ever be necessary is to reduce it to the state of a compound fracture by a simple incision, for there are few, if any, cases in which union does not take place in compound fractures." He ends his argument by the following statement: "I will close this dissertation on fractures by recommending free use of the lancet."

Instead of rendering a patient insensible either by the use of intoxicating liquor or by blood-letting, we now resort to anæsthesia to obtain muscular relaxation.

Local anæsthesia may be used. This form of anæsthesia in the reduction of fracture was first used by Conway,[26] in 1885, who reduced three cases of Colles' fracture and one posterior dislocation of both bones of the elbow by aid of a local anæsthetic. He advised injection directly into the fracture site, even though the fracture extended into a joint or into the hæmatoma about the site of fracture. This method was used by Reclus,[27] in 1903, Lerda,[28] in 1907, Quenu,[29] in 1908 and Braun, in 1913.

Hosford[30] advocates the use of novocaine, infiltrating around the fracture or into the hæmatoma at the site of fracture, or by injecting suitable peripheral nerves.

Mage[31] reports the use of regional anæsthesia by nerve block and advocates two methods to use: first, a field block which consists in creating an encircling wall of anæsthesia by infiltrating the tissues around the operative field, and second, nerve block which consists in making novocaine injection in close proximity to the nerve or nerves whose conductivity it is desired to cut off.

Gray[32] advocates the use of novocaine plus adrenalin chloride, but Wells in the discussion advised against using adrenalin because of the fact that the addition of adrenalin retards the desired rapid absorption of the novocaine. According to Wells one does not get good relaxation in local anæsthesia for the reduction of fractures in from 25 to 35 per cent. of the cases.

Bohler does not use general anæsthesia for the reduction of fractures. He advocates local anæsthesia to reduce all recent cases. In isolated cases he uses regional anæsthesia, infiltrating the tissues around the fracture with twenty to fifty cubic centimetres of a 2 per cent. solution of novocaine. In cases of fracture which are over two weeks' duration Bohler[33] blocks the brachial plexus to reduce fractures of the arm and advocates the use of spinal anæsthesia for fractures of the lower extremity.

The advantages of local anæsthesia are:

A surgeon may attempt reduction when an assistant or anæsthetist is not available.

Reduction may be attempted in those who are too shocked to receive a general or a spinal anæsthetic, or in those who refuse a general anæsthetic.

The patient can go to the X-ray room alone.

The duration of the anæsthesia is from two to three hours and if the first attempt is not successful subsequent attempts can be made.

Individuals with fractures of the upper extremities may go home immediately unassisted.

It may also be used in cases of decompensated heart or conditions which would contra-indicate the use of general anæsthesia.

The disadvantages of local anæsthesia in the reduction of fracture are:

It cannot be satisfactorily used in very young children.

It usually takes longer than a general anæsthetic.

It is contra-indicated in open fractures and cannot be used when there is very much swelling present because it is difficult to inject novocaine exactly at the site of fracture.

Spinal anæsthesia may be used to reduce fractures of the lower extremity when general anæsthesia is contra-indicated, but cannot be used in cases of shock associated with low blood-pressure, or in certain cases where the patient, because of associated injury, cannot be placed on his side.

My personal experience with local anæsthesia having been limited, my preference is a general anæsthetic, although for a short case such as a Colles' fracture nitrous oxide and oxygen may be used. Ethylene would be ideal were it not for the fact that proper reduction must often be accomplished in the fluoroscopic room, which renders ethylene impracticable.

General anæsthesia at the present time seems preferable, but with more experience in practice with local anæsthesia it may become popularized. General anæsthesia is not without risk because if the patient is not well under he may move at the crucial moment.

It is not my intention to discuss the pros and cons of operative or non-operative treatment of fractures. In this connection I am reminded of the words of Wilhelm Von Humboldt: "I lay very little stress either upon asking or giving advice. Generally speaking, they who ask advice know what they wish to do and remain firm in their intentions. A man may allow himself to be enlightened on various points, even upon matters of expediency and duty, but after all he must determine his course of action for himself."

An attempt has been made to emphasize the importance of early reduction with the least trauma. For reasons enumerated above any mechanical device which extensively tears the periosteum or traumatizes the tissues surrounding the fragments preëmpts the probability of delayed or non-union.

A large majority of fractures, if seen sufficiently early, can be reduced under an anæsthetic. The fragments can be held in good position by means of a properly molded plaster-of-Paris splint or case, skeletal traction or open operation. When reduction of the fracture is delayed or if the fracture is associated with swelling of the soft parts or considerable shortening of fragments exists any attempt to make forcible reduction by means of severe and rapid traction will do irreparable damage to the soft parts. The method of Soutter[34] is for this reason not advocated. For the same reason, although being a great admirer of Moorehead, his instrument is thought to be too

drastic. Gradual traction by means of ice tongs or pins is preferable to any rapid method as such gradual traction produces less trauma to the soft parts.

Hippocrates[55] mentions the use of extension and states that "for the most part two strong men will suffice." He advocates, "when the parts are adjusted you should apply the bandages while the limb is in a stretched position and when the limb is bandaged it should be placed upon some smooth or soft object so as not to be distorted to one side or the other, and that there may be no protrusion of the bones backward or forward, and for this purpose nothing is more convenient than a cushion or something similar, either of linen or wool, and not hard." He states that he is at a loss to advise that "gutters" below the fractured legs should be used, but found that a board is an uncomfortable thing to have a limb laid upon unless something be placed above it, but that it is useful in making subsequent arrangement of the bed or in going to stool. He found that as the swelling subsides in a satisfactory manner the bandaged limb will become more slender, the bones will be more mobile and yield more readily to traction. He states that the bones of the leg should get consolidated in forty days if properly treated and he cautions against tight bandaging. For the swelling which complicates a fracture he advised the part should be wrapped in unscoured wool, washed with wine oil and anointed with serate before bandaging, and if splints give pain they should be slackened. In speaking of fractures of the lower limb, he states that when the outer bone of the leg is broken the patient should soon walk about, but in fractures of the inner bone it is a long time before they can walk. "It is a disgrace," he says, "to exhibit a shortened thigh, for an arm when shortened may be concealed and the mistake is not so bad." In fact, he says that "when the sound leg is placed beside the broken one, the sound one being longer than the other, exposes the mistake and, therefore, it would be to the advantage of the person who would be improperly treated that both of his legs should be broken, for in this case one would be the same length as the other." In his experience the thigh bone should be consolidated in fifty days.

In speaking of the treatment of compound fracture, Hippocrates notes that: "In those cases of fracture in which the bones protrude and cannot be restored to their place the following mode of reduction may be practiced: Some small pieces of iron are to be placed below the levers which the cutter of stone makes use of, one being rather broader and the other narrower. There should be three of them at least and still more so that you may use those that suit best, and then, along with traction, we must use these levers, applying the under surface of the piece of iron to the under fragment of bone and the upper surface to the upper bone. In a word, we must operate powerfully with the lever as we would do upon a stone or a piece of wood. The lever treatment along with traction must be had recourse to on the day of the accident or the next day, but by no means on the third, fourth or fifth day for if delayed too long convulsions are apt to occur." In other words, Hippocrates realized the fact that when operation was indicated it should be performed early.

If the fragments of a fracture cannot be satisfactorily held by conservative measures it is far better to anticipate delayed or non-union and operate early, for, as pointed out by Whitman:[58] "Operative treatment in fractures is indicated when a satisfactory reduction cannot be obtained and maintained by non-operative methods, provided there is no contra-indication and when the expected result of the open method is sufficiently better than the closed to justify the additional risk." Open operation when employed should preferably be undertaken during the first week after injury. Fractures should be reduced immediately after the injury, but only when proper fixation apparatus is at hand.

The method of operation by means of internal or external fixation or by wiring, plating or bone graft is not the theme of this paper. It is interesting, however, to note that Horeau, of France, first advocated the wiring of fractures in 1805.

Early weight-bearing with proper fixation is of great assistance in the treatment of delayed union of the lower extremity, especially the tibia and fibula.

Memmel[37] quotes the axiom of Aristotle that movement is life. He never preached that immobilization was death, but only that immobilization carried too far was responsible for many evils and certainly immobilization is frequently carried too far in the treatment of fractures.

Bohler, on the other hand, warns against too short a period of immobilization for fear that "new shortening or bending take place." He advocates early active motion of joints and early weight-bearing provided there is proper external fixation. He prefers active motion to passive motion.

Although constitutional diseases may have but little effect on union, yet naturally the general physical condition of the patient must always be considered. Beneficial effects or irradiated ergosterol, vigantol and feeding of other foods rich in vitamins has been employed. Phosphorus has been given internally and the newer osophyte has been used.[38]

Knoflach,[39] in the administration of ergosterol in doses of five to ten milligrams daily, noted an increase of the amount and density of the callus as compared with that in the controls. This increase began in the third week of fracture and was particularly great in elderly persons and children. In persons aged more than fifty-five the time required for bony union was distinctly shortened, but in other patients and other periods of life the difference in this respect was not significant.

H. A. Swart,[40] with his studies on the effect of irradiated ergosterol in the treatment of fractures of rabbits concluded that the administration of this vitamin did increase the rate of healing or the amount of callus formation in fractures of the tibia and fibula. He showed that there is some evidence that the administration of irradiated ergosterol to animals by mouth will produce a calcification in blood-vessels and other soft tissues. He found the most significant factor in the rate of healing and in the union of experimental fractures of animals is the degree of apposition of the fragments.

Israel and Frankel[41] found that fractures in guinea-pigs do not heal if the animals are kept on a diet free from vitamin C. A mere restriction of the vitamin does not impair the formation of callus.

Sir Ashley Cooper, over a hundred years ago, in his lectures on delayed and non-union, mentioned the fact that the improper diet of sailors on long cruises might be a causative factor in non-union of fracture so prevalent among these sea-faring men.

In conclusion it is urged that:

(1) More time be spent in teaching the medical student and the interne the proper mechanical factors in the treatment of fractures.

(2) Cases of fracture be considered more as emergencies which require immediate reduction.

(3) Such reductions should not be attempted unless proper fixation apparatus is at hand.

(4) An anæsthetic is usually indicated.

(5) Those cases of fracture in which the fragments cannot be properly approximated and held be operated upon early.

(6) Immobilization should not be carried over too long a period of time.

(7) Active and passive motion should be instituted early.

(8) Weight-bearing with proper external fixation is advantageous.

(9) Proper coöperation between the surgeon, his assistant, the interne staff, the laboratory and the röntgenologist be demanded.

By these methods we can improve our fracture service, although probably never reach the ideal, for "ideals are like stars; you will not succeed in touching them with your hands but, like the sea-faring man on the desert of waters, you choose them as your guides and, following them, you reach your destiny."

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TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY

STATED MEETING HELD DECEMBER 7, 1931

The President, DR. GEORGE P. MULLER, in the Chair

CALVIN M. SMYTH, JR., M.D., Recorder

OSTEOGENESIS IMPERFECTA TARDA

DR. WILLIAM J. RYAN presented a boy, aged thirteen years, who, in March, 1929, fell from a scaffold about eight feet. He was immediately moved to St. Mary's Hospital. X-ray there showed a fracture of the surgical neck of the right humerus in good position and an intertrochanteric fracture of the right femur with slight decrease in the normal angle between the neck and the shaft. X-ray of the pelvis was negative for fracture. The fracture of the femur was treated first by the Russel method and after union had occurred a Whitman case was applied. This case remained on for eight weeks. On discharge, X-ray showed the fractures healed with abundant callus formation and in good position. Some time in the Fall, without any history of any injury having been given or being noted by the family, it was noticed that he walked with a decided limp, and on being questioned he complained of pain in the right ankle. X-ray at this time showed a fracture of both internal and external malleoli and a fracture across the lower end of the tibia with union in good position. Some time in February, 1930, he fell again and sustained a fracture of the left femur at the middle of the shaft. He was taken to another hospital, the fracture reduced and a case applied. This case remained on for six or seven weeks. Following its removal the boy was taken to school by an older brother in an express wagon and about three weeks after the case was removed while standing up beside his desk one day he placed his full weight on the left leg and turned and the femur gave way at the site of fracture. He was then brought to St. Mary's Hospital and X-ray at that time showed a fracture through the middle of the shaft of the left femur at the site of an old fracture. There was slight outward bowing, callus was small and was not well calcified.

Realizing that this was probably a case of osteogenesis imperfecta tarda, the history was further investigated with the following result: He fractured one clavicle at the age of five following a trivial fall; then followed fractures of the other clavicle and the left humerus following trivial falls. The fractures of March, 1929, have already been described; also the fracture of the right ankle. He then sustained the first fracture of the left femur and the recurrence of this fracture for which he was admitted at this time. This boy was born through a normal delivery and weighed 7 pounds, 11.5 ounces at birth. Labor was short and there was no toxæmia present. He was nursed for only two months, when the mother's milk stopped. He was given milk, water and Dextri-Maltose. He remained on this formula until one year of age. During this period he had no cod-liver oil and no green vegetables, but he did have orange juice. At fourteen months of age he fell, striking his head. A mass formed over the right parietal region. This mass

was described as being soft, and a physician stated that fluid was present and it would be absorbed. He did not walk until eighteen or twenty months of age. He did not talk until three years of age. His first teeth appeared at three months and the rest followed in normal sequence rather earlier than normal. He has had chicken-pox and measles. Aside from the fractures he has not been subject to illnesses. Two years before his admission he received diphtheria and scarlet-fever antitoxin. From the age of five years he has been under the care of a competent pædiatrician and in addition to regulation of his diet he was given calcium, acterol and ultra-violet light. From infancy he has been puny, although the other six children in the family are robust, though not very large. At this period, his mother thinks there is some improvement in his growth and general condition and that his present mentality is above the average. He plays as other children do and is active physically. He has had his tonsils removed. The mother and father are living and well. There have been seven pregnancies with one post-partum hæmorrhage as the only complication and there are no fractures in the rest of the family. In no part of the family history is there any knowledge of a susceptibility to fractures of the bones or to blue sclerotics on either side.

The boy is undersized. While his head is not large, his forehead is rather square. *Teeth.*—Good. *Tongue.*—Clean and moist. Tonsils, absent. No blue sclerotics were noted at that time. The heart, lungs and abdomen are negative. There is definite deformity in the left thigh with forward and outward bowing with some shortening of the leg.

Laboratory Reports.—Urine, normal.

Blood Count.—May 13, red blood-cells, 3,930,000; white blood-cells, 11,000; hæmoglobin, 75 per cent.; polymorphonuclears, 72 per cent.; lymphocytes, 28 per cent. Blood calcium, May 15, 9.6 milligrams per 100 cubic centimetres; blood phosphorus, May 15, 4.7 milligrams to 100 cubic centimetres; Von Pirquet, May 15, negative.

May 17, red blood-cells, 3,840,000; white blood-cells, 7,600; hæmoglobin, 75 per cent.; polymorphonuclears, 80 per cent.; lymphocytes, 20 per cent.

Blood chemistry, May 17, sugar, 75 milligrams per 100 cubic centimetres; urea nitrogen, 13 milligrams per 100 cubic centimetres; creatinin, 1.3 milligrams per 100 cubic centimetres. Basal metabolism, May 17, plus 14 per cent. Platelet count, May 19, 120,000 per cubic millimetre.

X-ray examinations of the skull and of all the other extremities were made.

May 17, 1930.—Plate of the skull shows the bone rather thin but there seems to be a normal calcification throughout the skull. The sella turcica appears to be normal and the sinuses are clear. Examination of the right wrist shows normal calcification with a tendency to increase at the epiphysis. The left shoulder is normal with evidence of an old fracture of the scapula and also of the clavicle, both of which are healed with normal calcification.

He was discharged May 20, 1930, after being in the hospital six days. The Whitman case was kept on for twelve weeks. This boy has been followed carefully and was also seen by Dr. A. Bruce Gill, who suggested the wearing of a brace on the left leg because this leg had a tendency to turn in. While wearing this brace, the boy fell and fractured the tibia at the junction of the upper and middle third; with the brace on the leg, this fracture healed rapidly. He has had no other fractures since although he has had numerous falls, but none of great severity.

In investigating the literature to obtain, if possible, some suggestions as to treatment other than those already known, the reporter found the work of Glassner and Hass and decided to try the administration of thymus gland.

He obtained a commercial preparation which this boy took fairly regularly for a period of six months, and in the year since this therapy was started he has had no other fractures.

As to the administrations of the thymus it was the ordinary commercial preparation of the desiccated gland that was used. It was given by mouth in five-grain doses once a day. It was brought out by the German investigators that apparently in man large doses could be given without any untoward effect. In their experiments, thyroid, parathyroid, egg albumen and other substances were compared. While parathyroid did give some favorable results, it did not compare with thymus. They studied two groups of patients and at the end of three months those who had received no thymus had fibrous union while those that received thymus have good solid union, the X-ray pictures showing that both cortical and medullary callus were well formed and solid.

NEW METHOD OF NEPHROPEXY

Dr. Irvine M. Boykin said that there have been devised numerous methods of suspending the ptosed kidney. In all of these operations the capsule proper is employed to hold the kidney in or near its normal position. At one time the operation of nephropexy was popular, but, judging from published statistics, the results were variable. During the last decade or more little has been heard of it. The reason for this is probably because of unsatisfactory results. The capsule proper is described in anatomies as being a substantial structure, but from a surgical standpoint this does not seem true. It is a flimsy structure consisting of a few layers of connective- and elastic-tissue fibres. Can such a structure, even with the aid of adhesions, hold the kidney permanently in place against gravity and loss of the kidney's normal support? Also, one finds in the description of these various methods of nephropexy no attempt to restore the normal axial planes. A failure to do this can result in torsion or kinking of the pedicle with interference of circulation and ureteral obstruction. It occurred to the speaker that a fascial transplant of a more substantial texture might be used in suspending the organ and that the fixation be done in such a way as to restore, at least, the most important axial plane: namely, the long. The procedure was first carried out on the fresh cadaver while the tissue were still pliable.

A lumbar incision is made of sufficient length to deliver the kidney. (Fig. 1.) Along the convex border of the kidney two flaps of capsule one centimetre in width are outlined and stripped over each pole down to the hilium. (Fig. 3B.) In anticipation of swelling of the kidney, resulting in damage to the parenchyma following suspension, the remainder of the capsule is stripped from the anterior and posterior surfaces.

The next step is to remove from the thigh a strip of fascia lata approximately 2.5 by 32 centimetres. A longitudinal slit is made in the centre of this, large enough to permit slipping the kidney through it. (Fig. 2A.) The limb of the loop thus formed, which will support the inferior pole of

the kidney, is shortened by overlapping or reefing. (Fig. 2B.) When the kidney is suspended, the shortening of the limb tends to restore the plane of the long axis: namely, a tilt of the upper pole toward the spinal column. The two strips of capsule which were turned down over the poles are now sutured to the superior and inferior limbs of the fascial loop, thus acting as a spreader to prevent impingement of the loop on the pedicle. (Fig. 3A.) The kidney is returned to its fossa (Fig. 3C) and the position in which it is to be fixed determined. The accuracy of this depends upon the imagination of the operator.

On either side of the lumbar incision near the posterior angle, a small
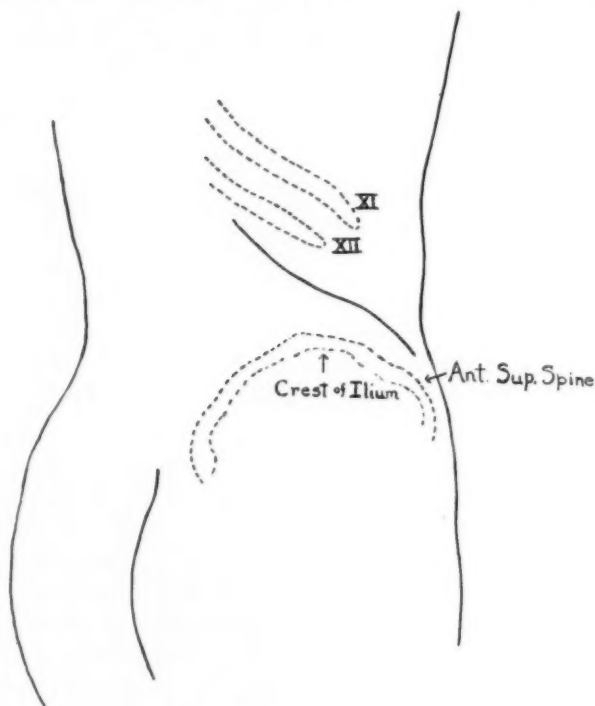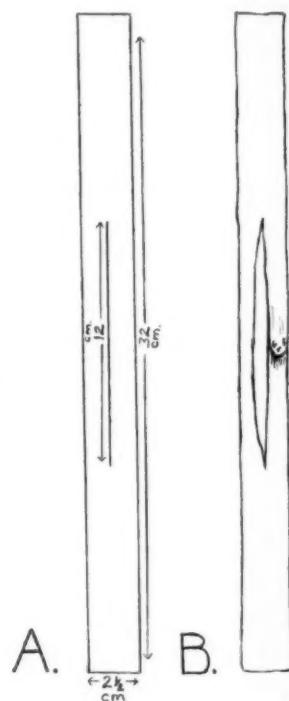

FIG. 1.—Incision.

FIG. 2.—(A)—Dimensions of fascial loop. (B)—Shortening of inferior limb by overlapping.

incision is made through all the muscle layers. These must correspond to the position the kidney is now held in. Through them are drawn the ends of the fascial transplant which are held taut while the vessels of the lumbar wound are being closed in layers. (Fig. 4A.) The ends of the transplant are then overlapped, still being held taut and sutured together. (Fig. 4B.)

To illustrate his remarks Doctor Boykin reported the following case:

A woman, aged fifty-four years, referred by Dr. John B. Haines, was admitted to the Episcopal Hospital June 23, 1931, with a history of pain in the right iliac fossa of five years' duration. The pain was constant, dull in character and radiating to the right thigh. Occasionally, the pain became severe enough to cause collapse. Partial relief could be obtained by reclining.

The points of importance in her past history were that she had borne two children, both difficult labors, demanding instrumentation. Following the birth of the second child, she was operated upon for a right inguinal hernia. Several years later a perineal repair and a suspension of the uterus was done.
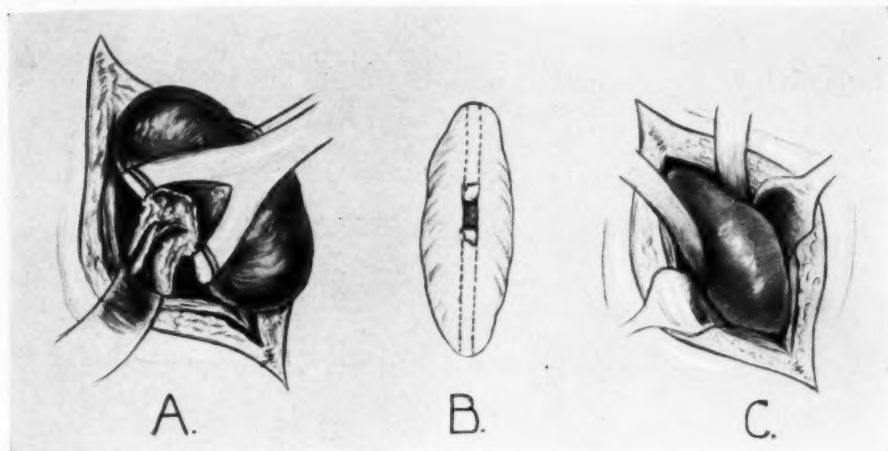

FIG. 3.—Method of suspending kidney with fascial transplant. (A)—Lateral view. Loops in place around kidney. (B)—Convex border of kidney. Strips of capsule outlined. (C)—Kidney suspended in fascial loops.

The abdomen showed two scars of previous operations. The muscle tone of the wall was very poor. The abdomen was pendulous, with marked diastasis recti. In the right iliac fossa the kidney could be palpated as a smooth, movable, tender mass. A previously gastro-intestinal examination showed a generalized splanchnoptosis.
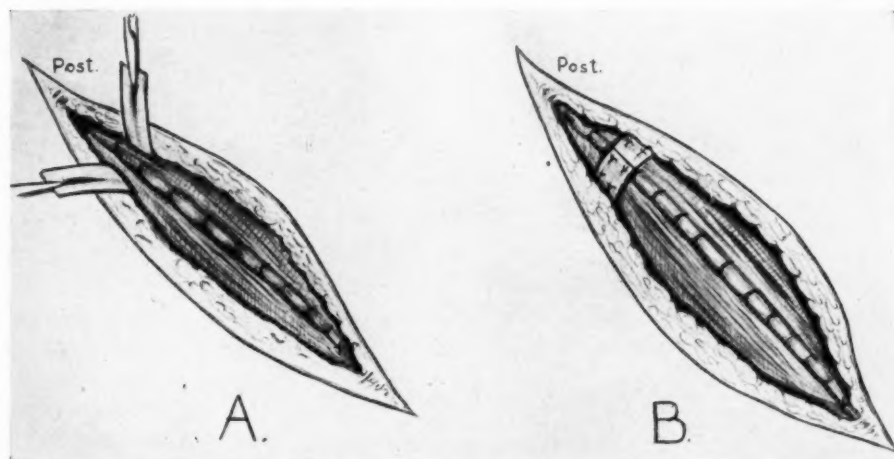

FIG. 4.—Closing incision. (A)—Fascia ends brought through muscle at post extremity of incision. (B)—Fascia ends overlapped and sutured.

Cystoscopical examinations, April 10, 1931, gave a bladder picture normal except for distortion of outline by extra-vesical adhesions. Pelvis filled with opaque fluid and pyelogram showed the low position of the right kidney with marked dilatation of the pelvis and kinking of the ureter. In the erect

posture the kidney lies about an inch lower than it does when patient is prone. (Fig. 5.) June 25, 1931, the woman was operated upon by the method described above.

A pyelogram made October 23 shows a slightly dilated pelvis but with normal major and minor calices. In supine position, the pelvis lies opposite the transverse process of the third lumbar. In the erect posture it lies about on the level of the fourth lumbar. (Fig. 6.)

Examination on December 3, 1931, showed the lower pole of the kidney palpable beneath the costal border. There was no tenderness. An indigo-carmine function test on this date was 8 minutes left side, 24½ right.

This operation has been done in one case only. While the speaker realized that its merit cannot be proven or disproven by this one instance, and although

FIG. 5.—Pyelogram before operation. Note dilatation of pelvis and clubbing of calices.

FIG. 6.—Pyelogram four months after operation. Pelvis slightly dilated. Calices wall deformed.

it has been only six months since operation, the results seem sufficiently satisfactory to make it worth while describing.

INTERLOBAR EMPYEMA DISCHARGING THROUGH A BRONCHUS (PLEURAL VOMICA), EXPLORATORY THORACOTOMY AND EXTRAPLEURAL THORACOPLASTY

Dr. Astley P. C. Ashhurst and Dr. Irvine M. Boykin presented a woman, twenty-two years of age, who was admitted to the Episcopal Hospital January 23, 1930, with the diagnosis "lung abscess."

As a child, she had had measles, chicken-pox, and mumps. Two years ago she had been in this hospital with a pelvic abscess, following abortion, which had been opened and drained by Doctor Ashhurst, by "vaginal puncture." From this illness she had made an uneventful recovery. On admission January 23, 1930, her chief complaint was cough and expectoration. This

had been going on for three weeks, during which time she had been sick in bed at home. She had been under the care of Doctor Nofer, who sent her to this hospital for X-ray examination of her chest. The report (January 3, 1930) was "marked density in right hilum, spreads down and out at about level of third rib anteriorly. At about the mid-clavicular line is an area of lessened density, within the dense area, which could be due to a lung abscess."

January 23, 1930, before her admission to the ward, Doctor Nofer punctured the right pleura because of physical signs of fluid, puncture about the angle of the right scapula drew nothing until after withdrawing the needle
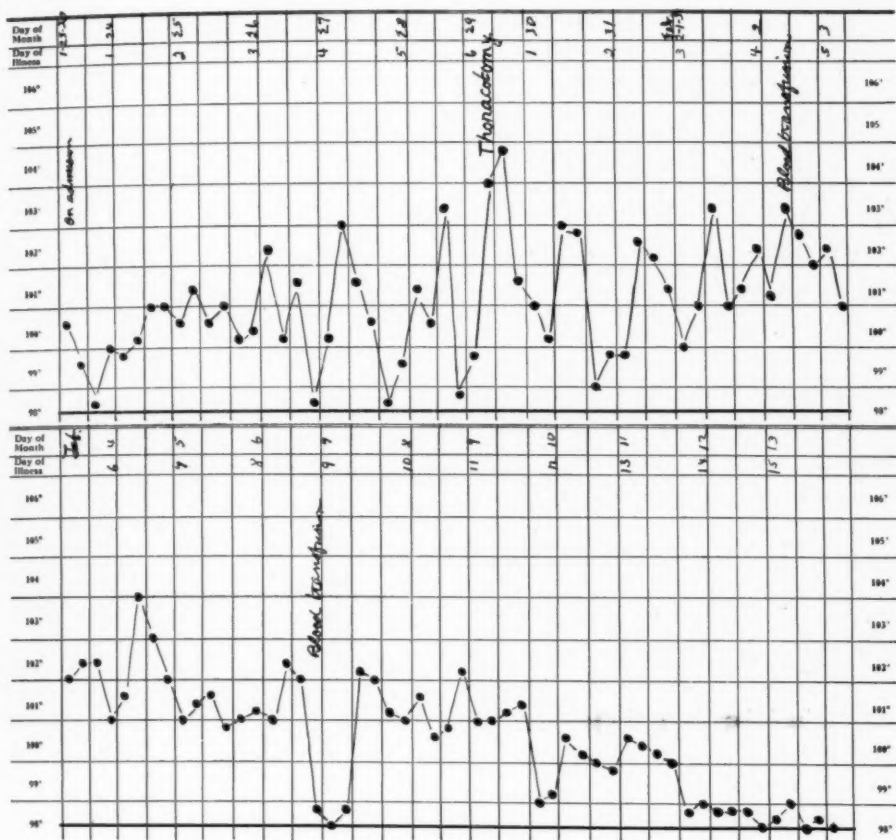

FIG. 7.—Shows the hectic temperature.

from its deepest point of penetration, with continued suction, he obtained pus about one inch inside the chest.

There was almost persistent and constant cough with expectoration of very foul-smelling mucopurulent material. (Fig. 7.)

Treatment consisted at first in "postural drainage," the patient lying on her right side in bed, with the foot of the bed elevated. She was seen in consultation by various members of the staff.

January 27, 1930, Doctor Ashhurst noted: "Patient sitting up in bed, left chest normal posteriorly except many squeaking and sibilant rales. Right chest shows impaired resonance at the base, increasing to dullness between the scapula and the vertebræ. Auscultation shows at the right base numerous

large bubbling râles; between the angle of scapula and vertebræ there is cavernous breathing. Above this level breath sounds are absent, except at apex, which is normal. Palpation for tactile fremitus was unsatisfactory owing to inability of patient to speak loud enough."

The patient since admission had been placed twice daily in the position for postural drainage, fifteen minutes each time, with head and body over side of bed so that patient is practically standing on her head. Results: January 25, 1930, 25 cubic centimetres; January 26, 110 cubic centimetres; January 27, 180 cubic centimetres.

January 28, 1930, thoracentesis drew 20 cubic centimetres of dark straw-colored fluid; upon standing, the lower part of the fluid remained straw-colored but without sediment, while the upper three-fourths of the fluid had a thick consistence and resembled the white of an egg. Two different punctures were made, and the same kind of fluid was obtained at both sites.

The first puncture was one interspace below angle of scapula, the second puncture in the same interspace, but in posterior axillary line.

During this time the patient's temperature ran a very septic course (Fig. 1) from normal up to 103°F., and she was gravely ill.

The medical consultant, and the Röntgenologist, thought she had a pulmonary abscess, and such was the receiving ward diagnosis. Doctor Ashhurst, however, concluded from the history, X-ray examination, clinical course and physical examination, that it was an encapsulated empyema discharging through a bronchus, with subsequent infection of the general pleural cavity, as the empyema, originally encapsulated in the interlobar fissures. (X-ray before admission (Fig. 8) began to leak at its periphery.)

The term "pleural vomica" has been in use for many years to describe an empyema communicating with and partially draining through a bronchus. Gould's Medical Dictionary (edited by Scott, 1926) defines *vomica* as "1. A cavity formed by the breaking down of tissue, especially a cavity in the lung. 2. (*vomere*, to vomit) a collection of pus in the lungs or adjacent organs that may discharge through the bronchi and mouth." Even Johnson's Dictionary (edition of 1828, which is a textual reprint of that of 1773) (which was the last revised by Samuel Johnson himself) defines vomica as an "encysted tumour in the lungs." Johnson quotes as follows from Arb. on diet (presumably Arbuthnot) "if the ulcer is not broke, it is commonly called a vomica, attended with the same symptoms as an empyema, because the vomica, communicating with the vessels of the lungs, must necessarily void some of the putrid matter, and taint the blood."

E. Mosny (Nouveau Traité de Méd. et de Thérap. Gilbert and Thoinot), (vol. xxix, pp. 222-230, Paris, 1910) says a vomica following interlobar empyema occurs late (six to eight weeks after onset of illness) whereas those which follow a primary abscess of the lung occur usually about fifteen days after the onset of the illness. The present patient's cough and expectoration began about two or three weeks after the onset of her illness. If Mosny's points of differentiation are correct, this would be in favor of the diagnosis of primary abscess of the lung, and against that of an encapsulated empyema. Most authorities at present appear to regard the differential diagnosis as very

difficult and as of little importance, since by the time a surgeon is consulted, the lesions have become indistinguishable.
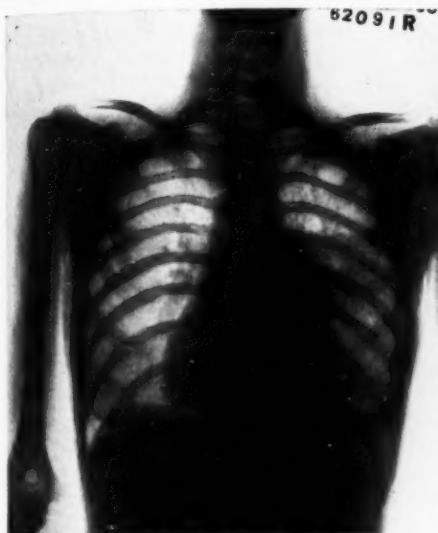

FIG. 8.—X-ray January 3, 1930, three weeks before admission.

FIG. 9.—February 4, 1930, six days after thoracotomy for empyema.

The prognosis of an encysted empyema discharging through a bronchus is poor, and it is difficult to find any accurate figures of the mortality.
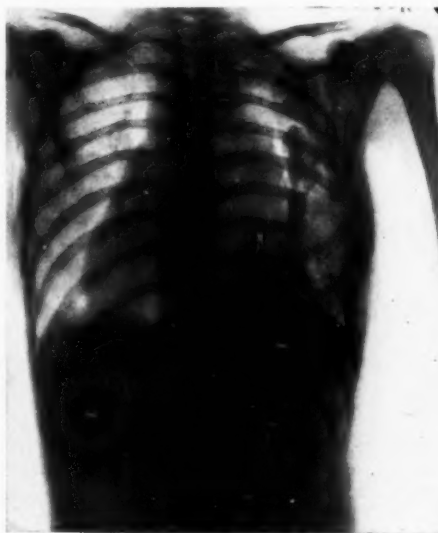

FIG. 10.—March, 1930, before first stage of thoracoplasty. Tube still in empyema cavity.

FIG. 11.—April 21, 1930, twelve days after upper thoracoplasty. Note the interval between ends of resected ribs, maintained by the intact lower ribs.

Doctor Ashhurst added that elsewhere (International Clinics, Twenty-sixth Series, vol. iv, p. 173, 1916; and Med. and Surg. Reports of the Epis-

copal Hospital, vol. iv, p. 226, Philadelphia, 1916), in advocating exploratory thoracotomy for cases of encapsulated empyæma and abscess of the lung, he had quoted Doctor Lord's statement (1915) that of five cases of pleural vomica under his care, only two recovered. Doctor Lord does not mention whether these patients were treated by operation or not. But the same author stated in 1919 (Osler Memorial Volume) that of unoperated cases of "lung abscess," the mortality is 63 per cent. In the paper just referred to, Doctor Ashhurst had recorded three cases of exploratory thoracotomy for pleural vomica (Cases I, V, and VI) with two recoveries and only one death (Case V). The present case, herewith recorded, makes a total of four patients with pleural vomica, treated by operation, with only one death.

First Operation.—January 29, 1930, *exploratory thoracotomy.* With the patient prone on the operating table, and under local anæsthesia, the tenth, ninth, and eighth right ribs were resected posteriorly and the pleura was widely opened; purulent fluid was found lying anteriorly in the costophrenic sinus, and the lung adherent to the dome of the diaphragm. The lung, which was rather firm to the touch, was easily detached by blunt dissection, and no pus was found between it and the diaphragm. But the lung was densely adherent to the spinal gutter under the fifth, sixth and seventh ribs, *i.e.*, the region overlying the interlobar fissure. Detachment of the lung from the costal pleura posteriorly gave exit to necrotic tissue, flakes of lymph and malodorous pus (the same as was being expectorated). A large iodoform gauze strip was placed in the abscess cavity in the lung tissue, and after removal of the isolating packs above the diaphragm, a second large piece of iodoform gauze, with a large rubber tube in its centre, was placed between the lung and diaphragm.

Throughout the operation, which consumed seventy minutes, there was no respiratory distress at any time, and no pain at all, except a little in detaching lung from spinal gutter. After this operation, the temperature continued to fluctuate, ranging from 99° to 103° F., but showing a tendency to reach normal, which it did six days after operation. (Fig. 9.) Blood transfusions were given February 2 (200 cubic centimetres) and February 7 (80 cubic centimetres). The second transfusion was followed by a reaction (without chill but with rise of temperature to 102° F.), which was nearly a week in subsiding.

From February 10 forward the patient was considered convalescent, her cough and expectoration being very much less, and sleep being secured without medication.

During March, the patient, who had been allowed out of bed for some time, developed a coryza, and had a recurrence of fever and slight cough. The physical signs of cavity in her lung remained practically unchanged, though there was not much discharge from the thoracotomy wound which required to be dressed only about twice weekly. (Fig. 10.) With the object of collapsing the cavity in the lung, Doctor Ashhurst determined to do a two-stage extrapleural thoracoplasty.

Accordingly, April 9, 1930, he removed the posterior portions of the first to seventh ribs inclusive. The patient's temperature had been practically normal for one week before this operation, and there had been no discharge from the thoracotomy wound. This was thought to indicate that the abscess was walled off on the pleural side. The length of ribs resected varied from three centimetres of the first rib to eight centimetres of the seventh. During

the operation, which was long (seventy-five minutes) and laborious, she had scarcely any pain. About sixty cubic centimetres of a 1 per cent. solution of novocaine were employed. In view of the subsequent regeneration of the resected ribs, it was an error not to apply Zenker's solution to the rib beds, as advised by Hedblom (Lewis's Practice of Surgery, 1930).

After the first-stage thoracoplasty the patient began again to expectorate more freely. Ten days after the thoracoplasty the temperature reached normal, and the amount of expectoration was diminishing. April 21, 1930, it was noted that there was clubbing of the index fingers and thumbs of both hands. April 24, 1930 (Fig. 11), examination indicated decrease in size of the cavity in the lung. Dr. Robert C. Colgan, medical consultant, noted: "Judging from X-ray, and physical signs, there is about one-third collapse of right lung, and a well-defined collection of pus between fifth and ninth ribs posteriorly and second and fourth ribs anteriorly. However, there seems to be ample drainage."

April 26, 1930, the *second-stage thoracoplasty* (postero-inferior) was done. The eleventh, tenth, ninth, eighth and seventh ribs were removed. The operation, done under local anæsthesia, lasted about ninety minutes, and was well borne. The old pyothorax cavity was unavoidably opened when resecting the eighth and ninth ribs, as the drainage tract of this operation was found to have become surrounded by the eighth rib which had re-formed since the original thoracotomy three months previously.

Profuse drainage followed from the original thoracotomy incision, as the second-stage thoracoplasty had much more effect in diminishing the size of the pleural cavity which had been the site of the pyothorax than had been the first stage, as the main effect of the latter was upon the cavity within the lung (*i.e.*, the original interlobar empyema). Four days after the second-stage thoracoplasty, when the gauge packing first was removed from the old empyema cavity, the same foul-smelling pus was encountered as was being expectorated. This was taken to indicate that the cavity in the lung had reopened into the empyema cavity.

May 4, 1930, so much drainage from the empyema cavity as to require dressing twice daily. (Fig. 12.)

May 13, 1930, postural drainage resumed today, morning and night, with patient resting on her hands on the floor, while her hips remain on the bed; not coughing or expectorating so much, and drainage from original thoracotomy wound is much less, while wound of second-stage thoracoplasty is almost healed.

May 16, 1930, requires to be dressed twice daily. Is pale and anæmic. No tubercle bacilli have been found in the sputum at any time, and only on one occasion have elastic fibres been found (but the examinations have all been made without special straining for elastic fibres).

May 19, 1930, the operation incisions are entirely healed, except for the sinus where the original thoracotomy was done; here a closed Kelly hæmostat can be introduced for about eight centimetres, and drainage appears adequate. It is dressed daily.

During June, 1930, the patient was out in the sunshine a good part of the time but was still confined to bed. She became tanned, and looked better.

June 25, 1930, the medical consultant, Doctor Colgan, reported: "Patient is draining freely from the wound, and expectorating two to three ounces daily of sputum. There is very little change in the physical signs over the right lung. Believe patient should be built up generally—for further operative work. There is still free drainage of pus from the abscess and bronchi-

ectatic cavities, and the probabilities are that more radical measures will have to be done in order to get her well (cauterization of lung or lobectomy)."
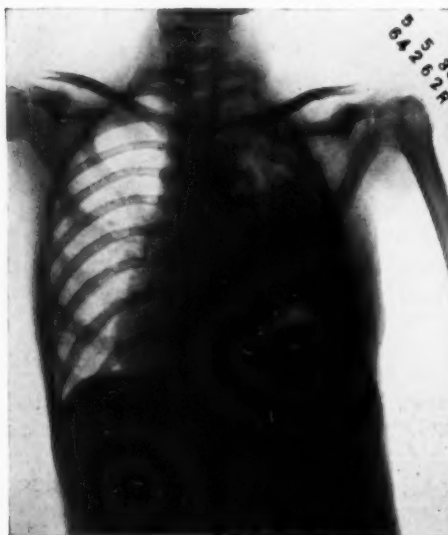

FIG. 12.—Nine days after second (inferior) thoracoplasty. One month after first stage. (May 5, 1930.)

FIG. 13.—Eight months after admission. (October 2, 1930.)

June 25, 1930, she spat up about four cubic centimetres of blood when doing postural drainage, during which periods she hacks and coughs very hard.
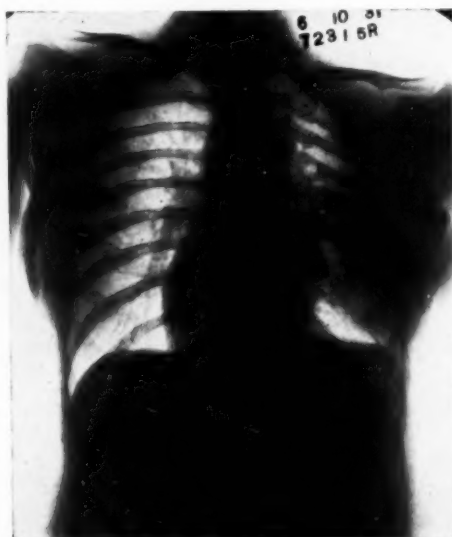

FIG. 14.—Eight months after leaving hospital. Healed firmly for six months. (June, 1931.)

June 26, postural drainage stopped for a time.

July 8, 1930, coughing and "vomiting" blood, and blood is coming out of

sinus of original thoracotomy wound. She is slightly despondent over her condition.

July 11, 1930, no more coughing of blood and no bleeding from sinus.

July 14, 1930, only slight drainage of mucopurulent material from wound. Condition improved.

July 29, 1930, Doctor Colgan reports physical signs in right lung indicate improvement. There is very little if any moisture in the upper fourth of right lung. Breath sounds are suppressed. Her weight at this time was eighty-nine pounds.

August 1, 1930, transfusion of 200 cubic centimetres of blood today.

August 2, 1930, operation by Doctor Boykin. Old scar including fistulous tract was excised between elliptical incisions; seventh, eighth and ninth ribs (which had reformed) were again excised, exposing a cavity which extended from ninth rib upward to fifth, lateral to mid-axillary line. So far as could be determined, this cavity of the old empyema does not communicate with
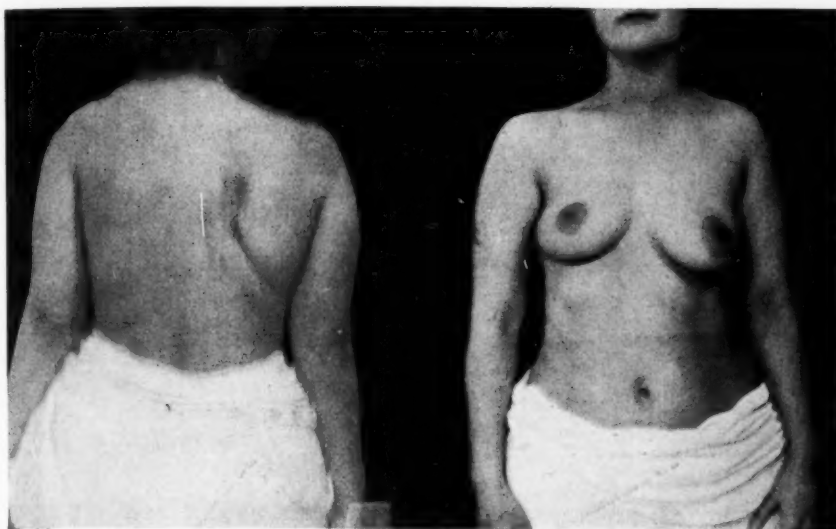

FIG. 15.—Photographs of patient one year after thoracoplasty. (June 10, 1931.)

the cavity in the lung. The operative cavity was packed firmly with iodoform gauze. Time of the operation, forty-five minutes.

August 26, 1930, Doctor Colgan (medical consultant) reports many coarse, crackling râles scattered throughout lower half of right chest, anteriorly and posteriorly. Upper third of right lung shows evidence of collapse, viz., suppressed breathing; no râles heard in this region. Believe more radical measures will be necessary before the lesion will be eradicated: deeper cauterization of bronchiectatic cavities and surrounding infected lung tissue.

August 28, 1930, wound still draining some. Cough diminishing, temperature practically normal.

September 17, 1930, sent to convalescent home at Oakburne, Pa.

September 27, 1930, readmitted. Weight 91¾ pounds.

October 11, 1930, X-ray examination after injection of lipiodol into the sinus. Marked regeneration of ribs which were resected, excepting tenth and eleventh. Upper level of sinus tract is at level of tenth rib. Somewhat thin line of the opaque medium is shown reaching downward and upward from it

to the chest wall. Still marked density in lower half of right chest in region of collapsed lung.

October 22, 1930, patient discharged finally from the hospital, her temperature having been normal ever since her readmission, and there being very little discharge from the sinus.

June 10, 1931, patient seen again in excellent health. The sinus closed before December 25, 1930, and has remained closed ever since. (Fig. 15.)

October, 1931, patient seen today. After walking some blocks from her home to the hospital, and then ascending rapidly two flights of stairs (forty steps), she felt scarcely at all out of breath, and looked in excellent health. Her weight is 120 pounds. She has a good job, doing light work with enjoyment. She has no cough at all and has not had since leaving the hospital.

December 2, 1931, the patient when presented at the meeting was in excellent health. The clubbing of the fingers has disappeared.

COMPOUND FRACTURE—GAS GANGRENE

DR. IRVIN E. DEIBERT presented a man, twenty-two years of age, who was admitted to the surgical service of the Cooper Hospital, Camden, N. J., October 14, 1930. While working in the third-story window of his home he fell out, his right arm being pinned underneath him. Upon admission the patient was in distinct shock, temperature 96.2°, pulse 122, respirations 22. The lower third of the right arm showed a laceration about two inches in length; the end of the radius had apparently protruded through the skin. The general physical examination revealed no other gross injury. The wound was cleansed, a sterile dressing and a temporary splint applied, patient put to bed and treated for shock in the usual manner. About four hours later he had reacted sufficiently to be taken to the operating room where nitrous oxide was administered, the wound inspected and cleansed and reduction attempted. X-ray showed that the reduction was not satisfactory. The following morning the general condition was not good, the arm was swollen and he complained of considerable pain at the fracture site.

Sixteen hours after admission the temperature rose to 102°, pulse 100, respirations 22, and the swelling had extended to the shoulder-joint. There was no crepitation present but a smear made from the wound showed a large number of bi-polar rods, chain cocci, and nails and spores, which were assumed to be *B. welchii, streptococci* and *tetanus bacillus*. The *B. welchii* were later proven by laboratory culture. On admission to the hospital the patient had been given 1,500 units of tetanus antitoxin; he was now given 100 cubic centimetres of the perfringens serum, the polyvalent serum not being available. Preparation for immediate operation was ordered, amputation at the shoulder-joint being anticipated.

After the administration of ethylene gas, the patient's condition became decidedly bad, marked cyanosis was present, the pulse was rapid and weak and at times imperceptible, the swelling in the arm had extended over the pectoral muscles almost to the root of the neck and it was felt that he would not survive a shoulder-joint amputation. Accordingly, the arm was incised deeply into the muscle structures from the shoulder to the wrist, important vessels and nerves being avoided as nearly as possible; the wound at the fracture site was greatly enlarged and the periosteum was found to be of a distinct brownish color which stripped readily from the bones for a distance of several inches above and below the fracture site. Twelve Dakin's tubes were inserted into the wounds which were then flushed with hydrogen peroxide, packed wide open with vaseline gauze and a molded plaster splint applied

to the arm. The patient was then returned to bed, the Dakin's tubes were connected to a large tank of oxygen which was allowed to flow into the wounds continuously, the rate of flow being controlled by the ordinary wash bottle. Fifty cubic centimetres of perfringens antitoxin were administered every four hours.

On the day following operation the patient's general condition had improved somewhat, the swelling had not increased and there was no further extension along the chest wall. Three days later the general condition had improved to such an extent that the oxygen was discontinued and there were no further administrations of serum. One week after operation the Dakin's tubes were removed. This procedure was followed by a rise of temperature which at first was thought to be due to infection but later proved to be serum sickness, which subsided after about three days. Sixteen days after operation healthy granulations were present in the wounds and the amount of discharge was very small. An attempt was then made to secure better alignment of the fracture fragments. The vaseline gauze was renewed and a plaster case was applied after the method of Orr. No further complications developed, so the case was allowed to remain on for a period of four weeks. After three dressings of this type, each case being allowed to remain on for an average period of four weeks, the wounds were entirely healed. Active physiotherapy was then started and good progress was made for about one month, when the wound at the fracture site again began to discharge. The patient was readmitted to the hospital, the wound at the fracture site was opened and several small sequestra were removed. This was again treated after the technic of Orr.

Seven months after the accident, X-ray showed a beginning separation of about one inch and one-half of the lower end of the upper fragment of the radius. A review of the previous films failed to reveal a fracture line at this site. About six weeks were allowed to elapse and when the fragment had definitely separated the patient was readmitted to the hospital and this fragment removed; prompt healing followed.

One year following the injury a beginning flexion contracture was noted. This was much improved by stretching and the use of a cock-up splint. X-ray at this time shows mal-union of the ulna and non-union of the radius. Function is good considering the type of injury. He is able to play the piano very well at this time.

DOCTOR DEIBERT remarked that with the steady increase of the so-called street accidents an increase in the number of gas-bacillus infections is seen in civilian practice. Most surgeons who treat these infections had their first experience with gas gangrene during the recent war. There have been many excellent articles published on the subject during the past few years, particularly The Treatment of Gas Gangrene, Henry Milch, ANNALS OF SURGERY, June, 1931, and Gas-Bacillus Infections in Civil Life, W. E. King, American Journal of Surgery, November, 1931. The consensus of opinion seems to be that best results are obtained by early high amputation and the use of polyvalent serum, both prophylactically and as a therapeutic measure.

The reasons for reporting this case are that it was, apparently, a very rapidly progressing and extremely virulent infection; the patient did not have a prophylactic dose of serum; he did not have a high amputation and finally there was a separation of a fragment of bone from a point where no

fracture was shown in the primary X-ray film. The fact that pure oxygen was run directly into the tissues infected may have influenced the course of the case.

DR. EDWARD B. HODGE recalled a case that had recently been under his care in which the deformity, fracture and result were very much the same as in Doctor Deibert's patient. Multiple incisions were made to cure the boy and he is now receiving physiotherapy. The speaker felt that serum had a very large influence in the patient's recovery and urged its early use.

DR. CALVIN M. SMYTH, JR., said that in the treatment of compound fractures by the Orr method it had been his practice to give a prophylactic dose of perfringens and tetanus antitoxin and he has had no case develop gas gangrene.

DR. I. E. DEIBERT said that at the time of admission the patient had very little done other than a superficial cleansing, since the patient was badly shocked. It has been the speaker's practice to give every patient with a suspicious wound a prophylactic dose of perfringens serum. This boy did not have it. He came in on a night when there was a change of internes and was the type of case which should have had it. The speaker felt that these compound fractures should be immediately cleansed and opened up wide. He rather believes that it does not make much difference whether the serum is given or not; the fact that one cleans them out is a step toward preventing anaërobic infection. Had he seen this boy he would probably have opened him up wide when he came in, after the technic of Doctor Orr.

DR. JOHN SPEESE said that there is a very serious question involved here. Are surgeons to give a dose of serum in every compound fracture because it is a compound fracture, or because it is to be packed with gauze and encased in plaster? Does Doctor Smyth give it because he is using the Orr method? It is rather new to the speaker to think that every compound fracture should be given a dose of serum.

DR. DAMON B. PFEIFFER thought that compound fractures should be regarded not only as emergencies but as fit subjects for the mature judgment of experienced surgeons rather than the early efforts of younger house officers. It is interesting and important to know that gas gangrene may often be treated successfully without sacrifice of a limb, but it is still better to realize that appropriate early treatment of compound fractures will, as a rule, prevent the development of gas gangrene. The majority of cases of compound fractures of the long bones present ideal conditions for the development of anaërobic infections: namely, laceration of muscle masses, devitalization of tissues and anaërobic conditions. Opportunities for contamination are almost omnipresent. It should, therefore, be the first concern of the surgeon to alter these conditions in such a way as to prevent its occurrence or serious development. Naturally, the extent of the surgery necessary is

modified by several factors, such as the type and location of the injury, the degree and probable sort of contamination, and the associated vascular and other injuries. The size of the external opening is no definite criterion of the amount of subcutaneous injury. The speaker had come to believe that practically all compound fractures should have an anæsthetic and careful revision of the wound, that free and open drainage should be provided and that complete immobilization should be provided in the early and dangerous period. Joint cavities when involved should, of course, be closed. For about two years he had been trying the principles of the Orr method with the greatest satisfaction. While it may seem revolutionary and unwise to cover up the lesions of compound fractures, he as yet has had no occasion to regret it. As a matter of fact, the superior immobilization and the freedom from meddlesome interference are great advantages which more than counter-balance the apparent disadvantage. The success and safety of the method of dressing, however, depend not so much upon the dressing as upon the good surgery which should precede it.

DR. HENRY P. BROWN said that he thought that in civil practice as contrasted with military, it made a difference whether the fracture is compounded from within out or from without in, the latter being more apt to carry infection into the wound. He has seen cases in which the fractures occurred from within outwards cleansed and the fragments replaced without extensive débridement. If the patient does show signs of infection the wound can then be opened and treated accordingly, but why open it up when it is not necessary?

DR. J. STUART RODMAN recalled the case of a boy who had an extensive injury to the soft parts of his thigh; no fracture. He did a rather extensive débridement on him and despaired of saving his leg; and some thought it should be amputated. He felt, however, that the patient would have died from shock had he amputated and since the femur was intact and also the blood supply, he contented himself with a fairly extensive débridement but did give him a prophylactic dose of perfringens antitoxin. He developed gas gangrene, however, and was given numerous doses of the same antitoxin and fortunately they were able to save him, as well as his leg, but with a stiffened knee-joint. One can develop gas gangrene even after using perfringens antitoxin as a preventive measure, although the speaker felt that if he had not used it he would have lost this boy, as infection with this type of organism leads, of course, to profound toxæmia, unless, as in this case, its clinical course is altered by the early use of antitoxin.

DR. CALVIN M. SMYTH, JR., did not quite agree with Doctor Brown regarding taking a chance with ultra-conservative treatment on the ground that it is easy enough to treat infection if it should develop later. This is quite contrary to the speaker's experience, which is that when infection develops in these cases one has an osteomyelitis to plague both surgeon and

patient for a long time. It is not a question of whether one can get away without débridement but it is certain that one gets very good results by extensive operation and does no harm. As to the administration of perfringens serum, he gave the serum routinely in these cases for two reasons: first, because gas infection is relatively common in this type of street accident, and secondly, because it was his practice to treat most compound fractures by débridement, packing with vaseline gauze and encasement in plaster: namely, by the Orr method. He has always felt that in employing this method that one of its hazards was the closing up and the exclusion of air from a wound quite possibly contaminated with the gas bacillus. While he has never had a case of gas gangrene following the employment of the Orr method, he has always given a prophylactic dose of serum. The only cases of gas-bacillus infection that have been reported as complicating the Orr operation have been those in which prophylactic doses of serum had not been employed. He did not mean to suggest that most compound fractures would develop gas gangrene if the serum was omitted any more than most street injuries would develop tetanus if the antitetanic serum was omitted, but it would seem to be a perfectly logical procedure to give a dose of the combined tetanus and gas serum in this and similar types of street injuries.

Doctor Deibert said that in the Camden vicinity the soil is particularly rich with tetanus bacilli. He has not had a case of tetanus in the hospital for some time now. Two or three years ago he had one or two cases a year. Now it would seem that there is a remarkable increase in the number of cases of gas infection. He did not go into the number of cases in the hospital because of the time consumed, but he supposed they had an average of two or three cases of gas gangrene a year and he felt that in street accidents, particularly compound fractures, a dose of polyvalent serum in addition to tetanus serum should be given. If one waits until infection develops it is too late and the patient will have a bad result. As to the conditions favoring anaërobic infection, he thought that when one packs a wound with vaseline gauze one is packing it wide open. One is certainly packing it wide open for drainage and it does not seem important whether one puts a case around it or not in so far as the anaërobic infection is concerned.

FRACTURE OF BOTH FEMORA—UNUSUAL COMPLICATIONS

Dr. Paul Mecray and Dr. I. E. Deibert reported the case of a woman in whom there had been a fracture of both femora with delayed union, who after open operation on one bone showed an apparent tendency to form callus more rapidly. This was complicated by the formation of multiple renal calculi, disappearing spontaneously after fracture healing, suggesting a disturbance in calcium metabolism.

The patient, twenty-one years of age, was admitted to the Cooper Hospital, of Camden, N. J., May 31, 1930, having been in an automobile accident the previous evening. X-ray examination showed a transverse fracture of the right femur about five inches below the trochanter and a transverse fracture of the left femur about six inches above the condyles.

On the morning of admission the patient was given nitrous-oxide anæsthesia and ice tongs were applied to the condyles of both femora, Thomas splints with the Pearson attachment were put in place and swung in the Balkan frame in the usual manner. During the following six weeks frequent X-ray films were made, the apparatus was constantly adjusted in order to maintain the proper alignment, the patient was quite ill and never very comfortable, but aside from the usual difficulty that one would experience in the management of fractures of this type no complications developed. At six weeks, X-ray showed the position of both fractures to be very satisfactory. At eight weeks, the extension was removed. A few hours following, marked deformity of the left thigh was observed and subsequent X-ray showed a posterior displacement of the lower fragment; there was considerable mobility of the fragments clinically. All laboratory examinations were negative; the blood calcium was 12 milligrams per 100 cubic centimetres of blood serum.

Two months after admission the patient was given spinal anæsthesia, and the fracture site of the left femur exposed; practically no callus was present and there was beginning eburnation of the fragment ends. The area was cleansed, ends of the bones were freshened and a six-screw Lane plate applied to the fracture site. Wound closure was made in the usual manner and a plaster spica applied, the patient making a good operative recovery. At eight weeks all extension apparatus was removed, operative wound entirely healed, X-ray showing the alignment of both bones to be very satisfactory with callus in large amounts.

Ten days following the removal of the extension, or about nine weeks after the operative procedure, the patient complained of a severe pain in the right loin and suffered a rigor, followed immediately by the passage of two small stones in the urine. Laboratory examination proved these stones to be of the calcium oxolate variety. X-ray showed that there were numerous small stones in the pelves of both kidneys and in the right ureter; the left ureter was apparently clear. This was confirmed by ureteral catheterization and pyelogram. The pain and fever continued, there was considerable tenderness and swelling in the right flank posteriorly and on November 4, a right perirenal abscess was incised and drained, culture showing colon bacillus. Following this procedure the pain and temperature disappeared and the patient was a great deal more comfortable, the general condition improved, the temperature remained slightly elevated and slight pain in the right loin was occasionally complained of.

December 9, 1930, the patient was again cystoscoped and ureteral catheters passed and the pelves irrigated, which seemed to add considerably to the comfort of the patient. Eleven days later she passed a small stone about the size of a pea. X-rays prior to the cystoscopy had shown these stones attempting to pass down the ureter. Following the passage of this stone the patient made a rapid and uneventful recovery and was discharged from the hospital January 4, 1931. She has remained in perfect health.

DOCTOR MECRAY said he reported this case as having unusual complications because of the large number of calculi and the fact that they were passed when the patient got on her feet. Renal calculi occur more often as a complication of severe fractures that keep the patient in a prone position for a longer time than is commonly supposed. We know they are seen in spinal fractures, but here, too, many of them would be overlooked but for the reason that they are shown incidentally on a film aimed at the spine.

PROBLEM OF DELAYED UNION AND UNUNITED FRACTURE

DR. HUBLEY R. OWEN pronounced the annual address on the above entitled subject for which see page 759.

DR. ELDRIDGE ELIASON remarked as to the definition as to what constitutes an ununited fracture. We used to think delayed union meant six weeks without solid union and that non-union meant twelve weeks without solid union. Today we know that is entirely too short a time for such a decision. For example, Doctor Owen mentions two children in the series whose injuries were considered as non-union or ununited fractures—one at the end of two and one at the end of three and a half months. The speaker recalled one case of his own in which both bones of the forearm were ununited for eighteen months and then after six weeks at the seashore in the air and sunlight, solid union was obtained. The causes of non-union, as Doctor Owen brought out, are local and constitutional. Among the constitutional causes, as well as the local causes of pathological fracture, for example, of which many result in non-union, only one or two constitutional diseases figure. For example, fractures of tabetic origin never unite. The local causes for non-union in pathological fractures are only four. Out of thirty causes of non-union, twenty-six have union in from 25 per cent. to 100 per cent. Sarcoma, endothelioma, multiple myeloma and hypernephroma show no records in the literature of having united. We can disregard or put in the background the constitutional causes unless we require an alibi. The local causes of non-union are pretty well defined: faulty fixation, faulty approximation, faulty blood supply. We also notice three major local sites in the body for non-union in the shafts of the bone; this excludes short bones and articular fractures, especially fractures of the neck of the femur. These local sites are, lower end of both bones of the leg, tibia, fibula, the upper limitation of the lower fourth of the radius and the middle of the shaft of the humerus. All of these are interesting from the standpoint that one or more of the three causes are certainly responsible, viz., faulty fixation, faulty approximation, or faulty blood supply. Faulty fixation is open to question. The fact that ribs and clavicles unite although they are moved with every respiration indicates this may be a provision of nature at these two sites. Faulty approximation is extremely important, not only with reference to the time elapsed before approximation is accomplished, but also with regard to the number of attempts made to accomplish a satisfactory approximation. We know, for example, that comminuted fractures rarely, uncomplicated by infection, are the site of non-union, but repeated attempts at reduction have a tendency to interfere with the solid union. Doctor Owen brought out the point that early treatment, i.e., emergency treatment of a fracture, is essential because the earlier the surgeon gets the case the easier it is to reduce, the easier it is to hold in position, and the less often does one have to attempt to put it in position. Frequent attempts at reduction increase complication. A fracture should be handled and treated by an individual, not by five or six.

The man who treated it in the beginning should handle it throughout, and for that reason in the University of Pennsylvania Hospital the assistant on each service is notified when a fracture is brought into the hospital. It is taken immediately to the fluoroscopical room and the reduction is accomplished. The assistant, with an experience of two, three or four years, or the chief, then supervises the reduction under the fluoroscope, permitting the interne to do the actual work when advisable. The results have been very interesting. Ten years ago only 7 per cent. were reduced under twelve hours after admission. Between the years of 1925 and 1928, when the fluoroscope began to be used satisfactorily, reduction was increased to 43 per cent., and between 1930 and 1931, satisfactory reduction under the fluoroscope together with the above-stated régime of experienced supervision was increased to 80 per cent. That meant 80 per cent. of the cases that came in had a definite permanent reduction in from an hour to an hour and a half after the case was admitted. That meant that many of those cases could go out the next day, that the films were reduced from twelve per patient to three, that the expense of the X-ray department was reduced approximately 60 per cent. What effect has that on the patient's union? Simply this: In the last ten years at the University of Pennsylvania Hospital cases of shaft fractures followed up on shafts of the bone treated there showed that only two-tenths of 1 per cent. resulted in non-union. According to Groves and others—as stated by the essayist—this figure ranges from .5 to 4 and 5 per cent., so that attention to these cases, treating them as emergencies by individuals, with the proper supervision, has produced better results. The after-treatment as mentioned by the writer is very important. Blood supply likewise is extremely important for the union of a fracture. If you do not have blood supply, you cannot have union, and blood supply depends largely on activity. Which is the best way to get it? The physiotherapy given by the patient, together with aided active motion is the best. *Make him responsible.* Impress upon him that he must work out his own salvation.

BRIEF COMMUNICATIONS

INGESTED RIFLE BULLET REMOVED FROM THE URINARY BLADDER

The following case is reported as a contribution to the unusual and, sometimes, almost unbelievable performances of foreign bodies which have entered the human system.

M. S. A., a soldier, came under my observation in February, 1920, while I was chief of the surgical service at the Station Hospital at Camp Meade, Md. He stated that in August, 1919, he stumbled while going down stairs and accidentally swallowed a rifle bullet which he was holding in his mouth, and that following the swallowing of the bullet various sequelæ followed without the bullet being passed. The reason for admission to the hospital was on account of some blood in the urine and also pain at the end of micturition. The soldier was very carefully questioned as it was felt that he was mistaken about passing the bullet, but he was very insistent that it had never passed as he had carefully examined all his stools since the time when he had swallowed the bullet. At first it was not suspected that there might be some relationship between his complaint on admission and the ingestion of the bullet, and it was not until a careful physical examination had been made and an X-ray taken that much credence was given to his story.

Fig. 1.—Shows bullet as removed at operation. The deposit of salts which covered the base of the bullet was broken during removal, but the ogive end shows the characteristic appearance of the bullet at the time of operation and also as it appeared on the cystoscopical examination.

The history showed that about three weeks after the accidental ingestion he began to have pain at stool associated later with diarrhœa in which there was some fresh blood. He reported to his regimental infirmary for this condition and was under treatment for about ten days, after which time the diarrhœa and the pain which he had had on defecation cleared up. Following this he felt perfectly well and had no further trouble for about three months, after which time he noticed that there was considerable blood in his urine and also that he had pain on micturition. The hæmaturia gradually cleared up but the pain at end of micturition persisted. An X-ray revealed a rifle bullet in the pubic region and apparently lying within the bladder. Cystoscopical examination showed a salt-encrusted rifle bullet adherent to the posterior wall of the bladder.

March 8, 1920, the bladder was opened through a suprapubic incision. The bullet could be seen adherent to the posterior wall of the bladder, and was removed. It was completely covered by a deposit of salts, which had, however, not changed the contour of the foreign body, some of this calcareous covering became broken while the bullet was being removed. (Fig. 1.) The deposit on the anterior aspect of the bullet was considerably thicker than on the posterior surface which was in contact with and adherent to the bladder wall, the deposit at this point being very thin and in places practically absent. At the site from which the bullet was removed there was a small scar, but whether this was the result of the bullet entering the bladder at this point or was the result of the contact of the foreign body with the bladder wall could not be determined. No sinus was found in the bladder wall.

At first the possibility of an ingested rifle bullet passing into the bladder seemed rather far-fetched, but the history in this case was so clear and the

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chronological sequence of events so significant that this possibility could not be discarded, the more especially when one considers the anatomy of the region, which must have of necessity been traversed by the bullet in order to have given rise to the chain of symptoms which followed the swallowing of the bullet.

Anatomically, there is an area where the rectum and the urinary bladder lie in close approximation to each other. (Fig. 2.) The area is limited above by the reflection of the peritoneum over the posterior superior portion of the bladder, the retrovesical fold, below by the prostate, while the anterior rectal wall and the posterior wall of the bladder are separated by the posterior periprostatic (Denonvilliers') fascia. There is, therefore, an area where the rectum and the bladder are closely approximated but are separated by a space which is entirely extraperitoneal. If, therefore, a foreign body of the shape of a sharp-pointed rifle bullet should come down through the rectum in such a way as to engage the point on one of the transverse folds or plicæ recti, the point might hold and prevent the bullet from being passed. Successive stools would tend to cause the bullet to penetrate farther through the walls of the rectum. It was probably this condition of affairs which gave rise to the initial symptoms: namely, pain on defecation and blood in the stools. Later, after the bullet had penetrated through the wall of the rectum and had entered into the extraperitoneal space between the rectum and the bladder, the symptoms subsided and a period of quiescence ensued. Again, at a later
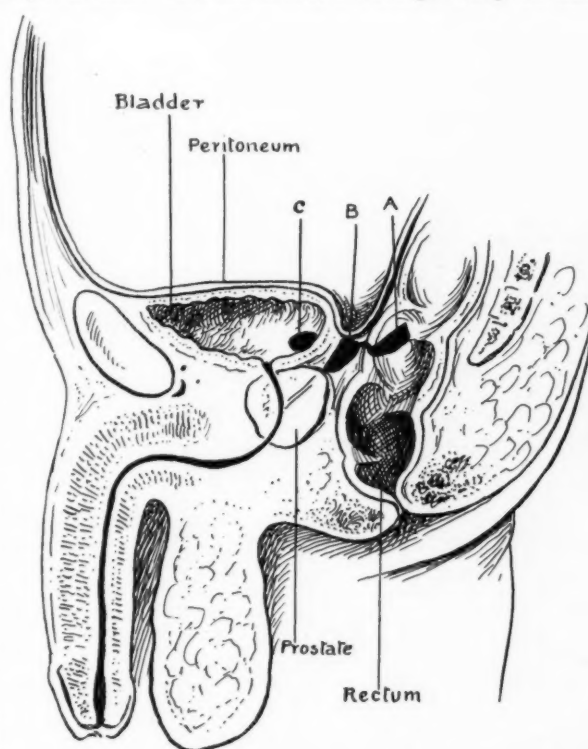

FIG. 2.—Diagrammatic representation of the course taken by the bullet as described in the text. A—First phase represented by pain on defecation and by bloody stools. Bullet caught in mucosa and gradually eroding through the wall. B—Second phase or period of quiescence. Bullet is lying in the extra-peritoneal space above the prostate and below the retro-vesical peritoneal fold. Bullet entirely extra-peritoneal and giving rise to no symptoms. C—Third phase. Bullet has eroded through the posterior bladder wall and is causing pain on micturition and also hematuria. Bullet found in this location on cystoscopic examination, and on supra-pubic cystotomy.

period, the erosion through the bladder wall caused a new chain of symptoms which were manifested by hæmaturia and by pain on micturition.

It was following this last manifestation, and especially the pain on

micturition, which caused his admission to hospital for observation, at which time the bullet was found and removed. The convalescence was uneventful, there were no further symptoms and the soldier was returned to duty May 18, 1920.

Several points present themselves for discussion in this case: (1) The possibility of this bullet having been introduced into the bladder through the urethra. The train of symptoms following the ingestion of the bullet were so clear that there did not appear to be any doubt as to the route traversed by the bullet, and furthermore, I doubt if an ogive-shaped bullet of calibre 30, the base of which has the same diameter as a 24 French sound, could be introduced into the bladder through the urethra. If introduced base up the square end would catch on the urethra, and furthermore would probably be blocked when the posterior urethra was reached. If introduced point first the sharp ogive tip would be liable to engage at several points along the urethra and also probably at the membranous urethra and thus prevent further progress. The fact that the bullet was adherent to the wall of the bladder strengthens the theory that the bullet entered the bladder by the route described. If the bullet had been introduced into the bladder through the urethra it would in all probability have been found lying free in the bladder instead of being adherent to the bladder wall.

(2) The slow penetration of the bullet through the rectal wall and then through the bladder wall probably accounts for the apparent lack of extravasation as healing would take place as the bullet passed along. Rapid entrance, however, does not necessarily cause extravasation as was shown in a case I reported in 1916 in which a soldier was wounded by a shrapnel bullet, the bullet passing through the sacrum, around the rectum and then into the bladder and not giving rise to any symptoms.[1]

(3) The lack of constitutional signs in this patient was due to the fact that there was no extravasation and that the course taken by the bullet in passing from the rectum to the bladder was entirely extraperitoneal and the healing occurred as the bullet passed along, thus precluding any sinus formation.

(4) It is realized that the evidence as far as ingestion of the bullet is concerned is circumstantial, but the sequence of events appears to be of such a nature that they could not be manufactured by anyone not conversant with anatomy, and for this reason we cannot disprove the fact that the bullet was probably ingested and took the course as has been described.

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DUCK BONE IMPACTED IN LOWER END OF ŒSOPHAGUS. EROSION OF ŒSOPHAGEAL WALL. FATAL HÆMORRHAGE

CASE.—M. G., a single man, aged forty-three years, was first seen November 3, 1930, complaining of pain in lower chest and epigastrium since he had swallowed a duck bone four days before.

He remembered distinctly swallowing the bone, and described it as one or one and one-half inches in length. Immediately afterward there was sharp retrosternal pain which radiated to the right axilla and back. Since that time he had continued to notice sharp pain on swallowing definitely located as posterior to the lower third of the sternum, sometimes radiating to the right chest. He had not consulted a physician and had had no treatment.

November 3, just before being seen, he vomited a small amount of light reddish blood. He had had no previous medical care for this illness.

Examination showed a well-developed man, not acutely ill, apparently lying in bed in some discomfort and restlessness.

He was seen again at 7 P.M. There had been no further bleeding, but as he had passed a somewhat restless day, and was uneasy, he was taken to Harper Hospital. On

FIG. 1.—Duck bone impacted in lower end of œsophagus causing fatal hæmorrhage from vessels in wall of œsophagus.

admission, he complained of considerable pain in the lower chest, costal margin area. He could swallow liquids, but solids went down with difficulty.

At 3 A.M. he vomited about 500 cubic centimetres of clotted blood streaked with bright red blood. The pulse went to 100, but the patient's general condition remained unchanged. At 8 A.M. temperature was 98.6°, pulse 96, respiration 20. At 8:30 A.M. he vomited 500 cubic centimetres of dark blood streaked with bright red, became pulseless for fifteen minutes, but responded well to 500 cubic centimetres intravenous glucose. At 10:30 A.M. 300 cubic centimetres more were given intravenously and the general condition improved slightly. At 11 A.M. the pulse became weak and the respirations more labored and at 12 noon the patient expired.

Post-mortem. (Dr. G. S. Bates.)—The stomach was removed intact together with 6 centimetres of the lower œsophagus and all of the duodenum. When opened about 800 cubic centimetres of dark blood, mostly clotted, escaped from the stomach. Among the

clots was found a bone shaped like a boomerang, 5½ centimetres in length, 5 millimetres wide at its centre, and 2 millimetres thick. (Fig. 1.) One end was sharply pointed and the other more blunt, but with a sharp edge. There was no free blood in the œsophagus. Three centimetres above the sphincter cardia were two puncture wounds at the same level in the œsophageal wall, 2 centimetres apart (measured on the opened contracted œsophagus). Both wounds extended through the submucosa into, but not through, the muscular coat of the œsophagus. There were small submucous and intramuscular hæmorrhages at each point, and a longitudinal blood-vessel could be seen coursing directly beneath the mucosa in close proximity to one of these wounds. The ends of the bone found free in the stomach seemed to fit exactly into these puncture marks. At the gastric edge of the sphincter was a small irregular laceration of the mucosa, 3 millimetres long. There were no other lesions of the mucosa to be found in the œsophagus, stomach or duodenum. Death had been due to hæmorrhage from the lower portion of the œsophagus, following trauma to its wall by the ingested foreign body.

The impaction of a foreign body in the supradiaphragmatic portion of the œsophagus is unusual. Chevalier Jackson states: "Almost all foreign bodies are arrested in the cervical œsophagus at the level of the superior aperture of the thorax (below the cricopharyngeal or first constriction, and corresponding with the seventh cervical or first dorsal vertebra). If dislodged from this position the foreign body usually passes downward to be arrested at the next (aortic) narrowing (level fourth thoracic vertebra) or to pass into the stomach."

St. Clair Thomsen plotted the location of 135 reported foreign bodies in the œsophagus. The chart shows four lodgements below the seventh dorsal vertebræ in cases in which the site was stated exactly, and eight localizations in this region where "the localization was given in more general terms." "The grouping of almost all the cases in the upper third of the œsophagus is very striking and coincides with the experience of all œsophagoscopists. Most of the very few cases of lower lodgement encountered have been pushed down by blind methods."

Similarly, in Gittins' recent report of thirty-six foreign bodies in the œsophagus, twenty-four were lodged in the upper third, seven in the middle third, and one in the lower third.

Just why foreign bodies usually lodge at the level of the superior thoracic aperture is not quite clear. This is not one of the well-defined anatomical narrowings of the œsophagus. Jackson's opinion is that in addition to there being a physiological narrowing here due partly to spasm, there is also (and more important) the fact that the cervical œsophagus is a collapsed tube surrounded by more powerful muscles, while the mediastinal œsophagus is constantly being pulled open by the negative intrathoracic pressure. Hence, once a foreign body passes the thoracic aperture, unless of unusual size or shape, it tends to be relieved and finds its way downward.

The termination by fatal hæmorrhage apparently from a vessel in the wall of the œsophagus is also unusual.

Most fatal terminations from foreign bodies in the œsophagus are due to perforation of its wall, causing mediastinitis, lung suppurations, gangrene, *etc.*, or perforation into a large adjacent blood-vessel, usually the aorta. It is not common to find record of a death due to hæmorrhage from a vessel

in the wall of the œsophagus caused by penetration of a foreign body. Poulet, in 1880, listed thirty-three reports of fatal hæmorrhages from perforations of the œsophagus and blood-vessels. There was only one among them due to rupture of an œsophageal artery. His list follows: Aorta, 17; carotid left and right, 3; superior vena cava, 2; inferior thyroid, 1; right coronary vein, 1; hemiazigos vein, 1; right subclavian vein, 1; œsophageal artery, 1; pulmonary artery, 1; unknown arteries, 4.

In our case, the foreign body was found in the stomach. However, the erosions in the wall of the œsophagus corresponded exactly with the sharp ends of the bone. Though the lesion was small, a superficial blood-vessel coursed directly beneath the œsophageal mucosa in close proximity to it. In this connection it is well known that many ulcers of the stomach and duodenum which bleed fatally are small; frequently no larger than the head of a pin.

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DIVERTICULA OF ŒSOPHAGUS

I NOTE in the January issue of the ANNALS OF SURGERY (p. 153), under the Transactions of the New York Surgical Society, a discussion concerning diverticula of the œsophagus in which I am quoted by Dr. Franz Torek, and I am writing to correct a statement by Doctor Torek which is unintentionally wrong.

There will always be a difference of opinion as to the best way to do things and it is desirable that this should always be present, as it accomplishes progress. I wish, however, to correct the impression given by Doctor Torek that the reason I advised passing bougies post-operatively following the two-stage operation for œsophageal diverticulum was that there were post-operative strictures. I advise passing of bougies post-operatively because of the fact that the constriction of the crico-pharyngei fibres which have to do with

the original production of the lesion is still present and if one would be logical in preventing further recurrence of a sac through the weak point in the posterior wall of the pharynx at the pharyngo-œsophageal junction, then some attempt, I think, should be made to dilate these fibres and to overcome any possible spasm in them. This is the reason why post-operative dilatation has been practiced and advised in these cases.

The name "pinchcock muscle" applied to the crico-pharyngei muscle, as the cause of pulsion diverticulum, was suggested by Dr. Chevalier Jackson, in whose clinic the one-stage operation is practiced. If there is a pinchcock effect before operation, there still is after operation by either the one- or two-stage operation and post-operative dilatation is necessary with either operative procedure.

There have been no cases of stricture and I do not believe that with the two-stage operation there is any real danger of stricture. There will, it seems to me, be a greater danger of stricture formation with the one-stage operation than with the two-stage, since in the one-stage operation one could easily remove too much œsophagus. The real danger in the two-stage operation is not that too much sac is removed but that not enough is removed.

It seems to me that Doctor Pool has stated the situation quite correctly as far as our views go. We have now operated upon thirty-three pulsion œsophageal diverticula with no fatality, many in very aged people, all of whom are swallowing quite satisfactorily. After all, the important thing with this lesion is safety, and if mediastinitis occurs after primary suture in the one-stage removal, there is very little that can be done about it. The two-stage removal is so safe and so satisfactory that I would personally feel that even if one patient in a hundred died of the one-stage and did not die with the two-stage, the two-stage would be my operation of choice.
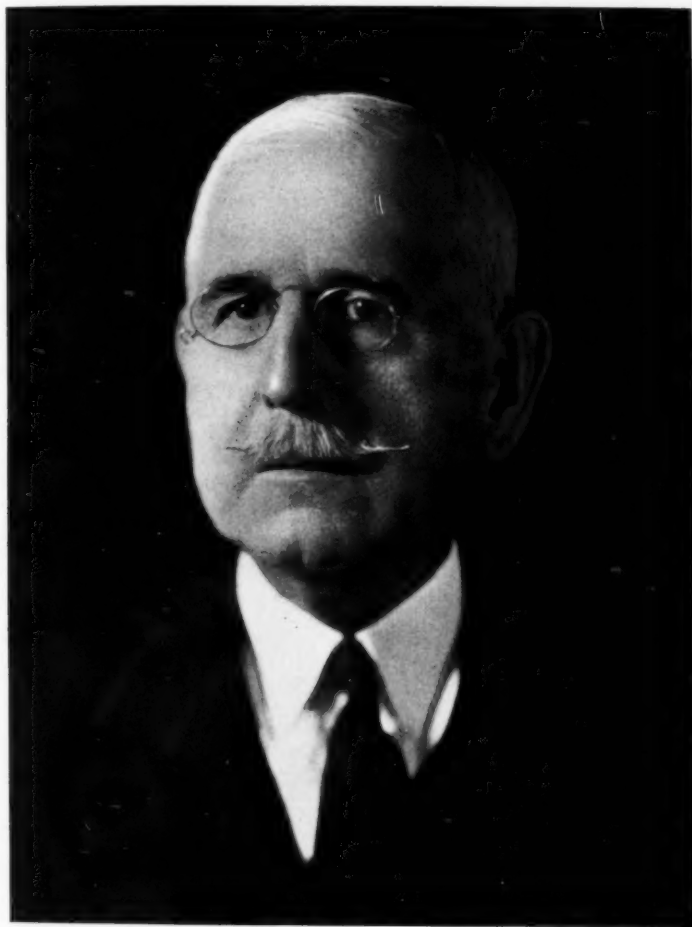
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MEMOIR
HARRY CLAY DEAVER, M.D.
1861–1931

DR. HARRY CLAY DEAVER was born July 23, 1861, in Buck, Lancaster County, Pennsylvania. His father was a general practitioner covering a large territory about this small crossroads hamlet. He had three brothers, two of whom studied medicine. The oldest, Richard, became a successful

HARRY CLAY DEAVER, M.D.

general practitioner in Germantown, Pennsylvania; John B. Deaver became an internationally know surgeon.

Dr. Harry Deaver was graduated from the University of Pennsylvania in 1885 and served as resident physician in the Episcopal Hospital, Philadelphia,

from April 1, 1886, to December 1, 1887. He was at once elected Dispensary Surgeon to that institution and in October, 1892, was made Visiting Surgeon which position he held until his death. In 1892 he was also made Attending Surgeon to St. Christopher's Hospital for Children, holding this position until 1908 when he retired to become Consultant. He served also as Surgeon-in-Chief of the Children's Hospital of the Mary J. Drexel Home from 1901 to 1931. From 1909 to 1922 he was Professor of the Principles and Practice of Surgery and Clinical Surgery of the Women's Medical College of Pennsylvania. He became a Fellow of the American Surgical Association in 1912. Doctor Deaver, while not so widely known as his brother John, enjoyed a very considerable local reputation and carried on a large practice throughout his life. He always kept a small proportion of general practice, chiefly among friends whom he had accumulated in the early period of his career. He liked these contacts and his brother John always maintained that it made him a better surgeon. However, the bulk of his work was surgical and was characterized by sound judgment, conservatism and thorough mastery of surgical technic. Had he chosen to write and speak to a larger public, there is no doubt that he could have achieved wide reputation. He preferred, however, a more secluded life and the well-merited confidence of his associates which he enjoyed. He died June 25, 1931, at his home in Wyncote, Pennsylvania, from cardiorenal complications following an attack of influenza.

DAMON B. PFEIFFER